



# The Business Value of BIM for Water Projects

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## Business Value of BIM for Water Projects SmartMarket Report

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## About Dodge Data & Analytics

Dodge Data & Analytics is North America's leading provider of analytics and software-based workflow integration solutions for the construction industry. Building product manufacturers, architects, engineers, contractors and service providers leverage Dodge to identify and pursue unseen growth opportunities and execute on those opportunities for enhanced business performance. Whether it's on a local, regional or national level, we make the hidden obvious, empowering our clients to better understand their markets, uncover key relationships, size growth opportunities and pursue those opportunities with success. Our construction project information is the most comprehensive and verified in the industry. We are leveraging our 100-year-old legacy of continuous innovation to help the industry meet the building challenges of the future.

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## Introduction

The technical complexity of water projects, and the intensity of operations and asset management functions at completed facilities, all suggest that BIM offers great advantages for this sector. Yet, in the 2012 *Business Value of BIM for Infrastructure SmartMarket Report*, the water sector had one of the lowest levels of BIM implementation of the seven infrastructure sectors examined, with only 30% of respondents reporting that they implement BIM on more than half of their water projects.

This new study, conducted five years later, strongly demonstrates the advance of BIM usage by engineers, contractors and owners in the water sector, bringing it very much in line with other sectors in terms of the benefits BIM generates, and highlights the unique aspects of BIM implementation for these projects.

One clear indication of the value respondents find in their use of BIM for water projects are the expected increases in use across project types.

- **Currently, among these BIM users, high implementation is already common in water/wastewater treatment plans and mining/industrial plants.**
- **However, we see many more respondents in two years expecting to use BIM for types of water projects on which it is less commonly used now, including tunneling and hydroelectric plants.**

Since most respondents do multiple types of water projects, this finding demonstrates that BIM experience tends to lead to wider BIM use in this sector. We also see a similar pattern for high levels of BIM implementation, suggesting that BIM use in the water sector is growing, especially among those that have already experienced its benefits.

One factor that stands out in the findings for the water sector, and that is very consistent with findings of previous Dodge BIM studies, is that **improved collaboration is seen as a top benefit of using BIM.**

- **Improved collaboration ranks first among the top business benefits reported by respondents.**
- **The top factor that would increase the benefits that respondents get from BIM is improved interoperability between software applications, which would directly support collaboration around the model between disciplines.**
- **Owner engagement through better visualization of the project in design is discussed as a top benefit in several case studies.**
- **Most respondents find that projects that include team members experienced in BIM have reduced errors and omissions, better ability maintain quality, better design solutions, reduced conflicts and coordination problems, and better communication from 3D visualization.**

While currently, most respondents do not report that BIM experience is required for the selection of design or construction teams, most of those who do not require that experience do encourage it, and as BIM experience becomes more common in the water industry, that is likely to shift, suggesting that companies currently not using BIM may need to acquire those skills.

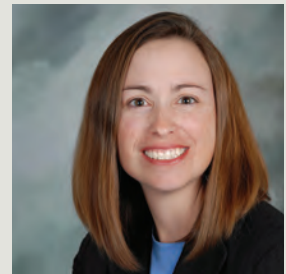
**One striking aspect of BIM use in the water sector is the attention paid to using the model during the operations phase of the facilities.** Most respondents (86%) report that on at least some of their projects, the model is integrated with asset management and/or used to support operations and maintenance activities. Increased owner interest in and use of models is also a recurring theme in the case studies, and it may be a critical driver for wider use of BIM in the water sector.

We would like to thank our premier partners Autodesk and Black & Veatch for their vision in supporting this research, and eBuilder and Pinnacle Infotech for helping to bring it to fruition.



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**Stephen A. Jones** leads DD&A's Industry Insights Research division. He is active in numerous industry organizations and frequently speaks at industry events around the world. Before DD&A, Jones was vice president with Primavera Systems (now part of Oracle), a global leader in project management software. Prior to that, he was principal and a Board of Directors member with Burt Hill, a major A/E firm (now merged with Stantec).



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**Donna Laquidara-Carr** currently provides editorial direction, analysis and content to DD&A's *SmartMarket Reports*. Prior to this position, she worked for nearly 20 years with DD&A's Dodge division, where she gained detailed insight into the construction industry.

# TABLE OF CONTENTS

## 04 **Executive Summary**

## 07 **Data**

### 07 **Introduction**

### 08 **How BIM Is Being Used in the Water Sector**

08 BIM Users in the Water Sector

09 **SIDEBAR Portrait of an Owner's BIM Journey**

### 10 **BIM Use for Water/Wastewater Projects**

10 BIM Use on Types of Water/Wastewater Projects

12 Most Frequent Project-Related BIM Activities

14 BIM Use During Operations Phase

15 **SIDEBAR BIM Meets Smart**

### 18 **BIM Benefits**

18 Top Business Impacts of BIM Use

20 Top Project Benefits of BIM Use

22 Top Industry Factors That Would Increase the Benefits of BIM in the Water Sector

26 **SIDEBAR Integrating BIM and GIS Data**

### 27 **BIM ROI**

27 Formal Measurement of BIM ROI

28 Most Important Factors Determining ROI for BIM Use on Water Projects

### 32 **BIM Investments**

32 BIM Investments

### 35 **Team Members and BIM**

35 BIM Requirements for Selecting Project Teams

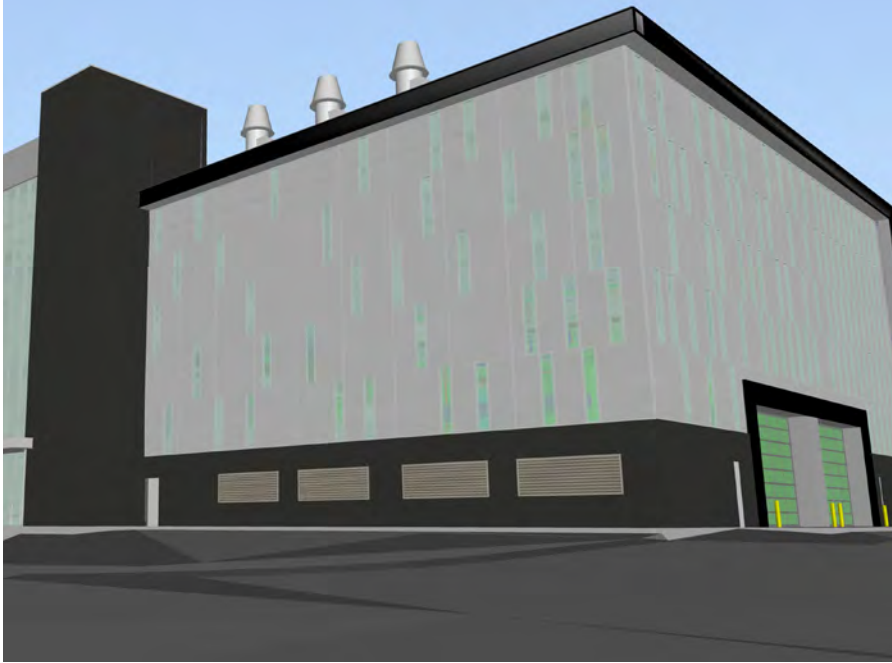
35 Use of BIM Execution Plans and Employer Information Requirements (EIR)

36 BIM Maturity of Project Team Members

37 Project Outcome Benefits Derived From BIM Use by Experienced Project Team Members

38 Project Process Benefits Derived From BIM Use by Experienced Project Team Members

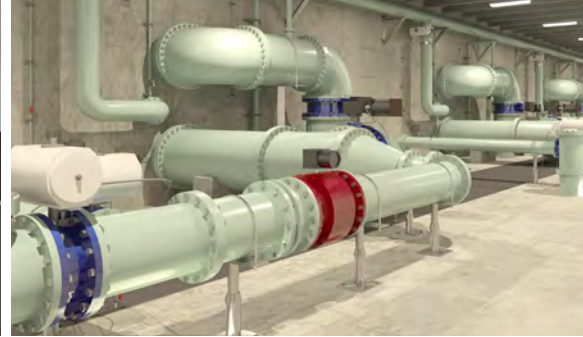
39 **SIDEBAR In the Pipeline: Design-to-Fabrication**



Front Cover:  
Tomahawk Creek Wastewater Treatment  
Facility aerial shot and detail.

This page left:  
Bonnybrook Wastewater Treatment Plant.

This page below:  
Filter pipe gallery at Southeast  
Water Treatment Plant.



## Case Studies

- 16 Pioneering BIM for Lifecycle Operations**  
Biological Nutrient Removal Facility at the EchoWater Project, Elk Grove, California
- 24 Transition to BIM**  
Southeast Water Treatment Plant, Guntersville Lake, Alabama
- 30 Demonstrating the Benefits of BIM on First Try**  
Liverpool Wastewater Treatment Works, Liverpool, UK
- 33 Better Coordination Through Visualization and Data Sharing**  
Tomahawk Creek Wastewater Treatment Facility, Leawood, Kansas
- 40 Expanding BIM Use Through Design and Operations**  
Plant D Expansion at Bonnybrook Wastewater Treatment Plant, Calgary, Canada

## Thought Leaders

- 42 Guy Voss, Director, Business Development, McCarthy Building Companies Inc.**
- 42 Michael Etheridge, Global Chief Engineer, Water, Black & Veatch**

## 44 Methodology

## 45 Resources

# Executive Summary

THE BUSINESS VALUE OF BIM FOR WATER PROJECTS

## Enhancing the ability to collaborate across project teams and beyond is a critical way that BIM creates value on water projects.

This study demonstrates a commitment to using BIM on water projects, with collaboration as a top benefit reported. The findings reveal that BIM use across the entire project team yields strong benefits, and that BIM use extends beyond the project into the operations and maintenance of the facility.

### Use of BIM in the Water Sector

#### LEVEL OF USE

Most of the participants in this study do multiple types of water projects, and all qualified to participate in the study because they use BIM on at least some of those projects. They were asked on which types of projects they use BIM now and expect to use BIM in the future in order to reveal the project types in the water sector that are most advanced in BIM use, and how quickly other project types are likely to catch up.

As the chart at right shows, BIM use is most common in water/wastewater projects and in mining/industrial projects. Nearly all of those who use BIM in the water sector are currently using it for these project types.

In two years, though, BIM use in the project types at the lower end now is expected to increase dramatically, narrowing the gap between highest and lowest use. This finding suggests that successful use of BIM on one project type encourages expansion to other project types.

A similar pattern is seen in the percentage of projects of each type on which BIM is used (referred to in the analysis of this report as BIM intensity), which is also highest currently in water/wastewater projects, but which is expected to grow dramatically for linear infrastructure and hydroelectric projects in the next two years.

#### TOP BIM ACTIVITIES

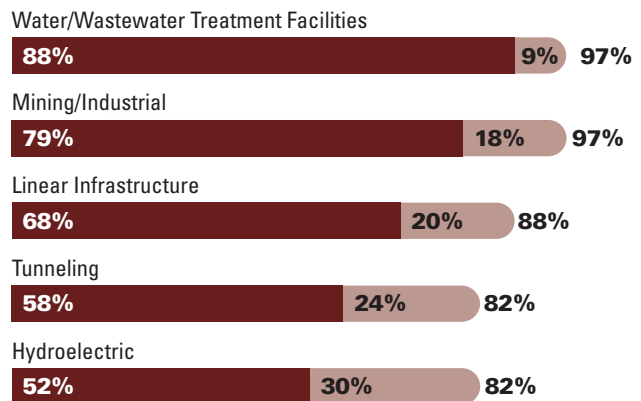
The most common BIM activities reported in the water sector are creation of bid/construction drawings and clash detection and avoidance. These are fundamental to the value that BIM brings to the design and construction process and commonly used activities in all project sectors according to previous Dodge research.

The third most common, selected among the top three BIM activities by nearly half of the respondents, is quantities and cost estimating integration. This is a particularly valuable process that can help save time and cost, and can help prevent waste.

### Use of BIM in the Water Sector by Project Type

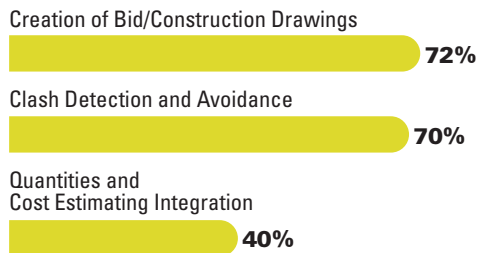
Dodge Data & Analytics, 2018

■ Currently Use BIM ■ Do Not Use BIM But Plan to Begin Within Two Years



### Top BIM Activities in the Water Sector (Selected as One of the Top Three Most Common Activities)

Dodge Data & Analytics, 2018



**USE OF BIM FOR OPERATIONS**

BIM is a full building lifecycle solution in the water sector. **Most respondents (86%) report that, on at least some of their projects, their models are integrated with asset management systems or that the models are used to support operations and maintenance activities.**

**Benefits of Using BIM in the Water Sector**

The top business and project benefits selected by respondents are relatively diverse, but they share one thing in common: They all have a broad impact on a project. Narrower, more specific benefits tended to be less frequently selected among the top three, suggesting that these are where they see the greatest impact on their businesses and project outcomes.

**BUSINESS BENEFITS**

**The top business benefit in the water sector from using BIM is the way it supports the ability of companies to work collaboratively with other members of the project team.** This is consistent with other BIM studies by Dodge in other sectors and other geographies, in which the importance and impact of BIM’s ability to support collaborative engagement are also evident.

**The other top business benefits are increasing client satisfaction and improving a company’s reputation as an industry leader.** These may be particularly relevant in the water sector because BIM use is still emerging, and the focus on these benefits shows that companies using BIM now are still reaping the benefits of early adoption. As the use of BIM matures in this sector, companies may need it to remain competitive.

**PROJECT BENEFITS**

The top benefits demonstrate that BIM helps to improve the creativity and reliability of project teams in the water sector.

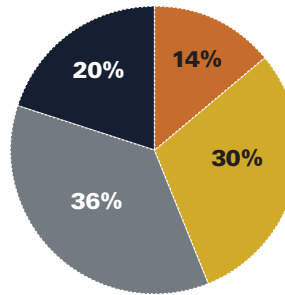
- **Over two thirds select better project design as one of the three top project benefits of BIM, suggesting that BIM allows for more creative and accurate design solutions.**
- **Reduced errors and omissions increases reliability of projects.**
- **Both of these contribute to improved project quality.**

**Use of BIM for Operations Phase**  
(For Asset Management and/or Operations and Maintenance Activities)

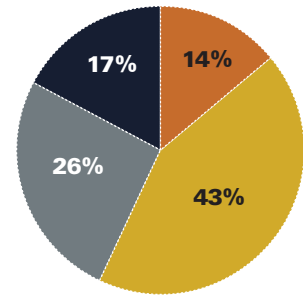
Dodge Data & Analytics, 2018

- None
- Low
- Medium
- High/Very High

**Integrating the Model With Asset Management**



**Operations and Maintenance Activities**



**Top Business and Project Benefits of BIM Use in the Water Sector** (Selected as One of the Top Three Benefits)

Dodge Data & Analytics, 2018

**Top Business Benefits**



**Top Project Benefits**



**INDUSTRY FACTORS THAT CAN IMPROVE BENEFITS**

Water sector respondents report that improved interoperability between software applications is the top factor that would improve the benefits they can achieve from BIM. Not only would this enhance collaboration, but it would also help utilize BIM more effectively for facility operations and maintenance activities. More widely accepted BIM standards is another factor that many consider important to improve the effectiveness of using BIM across a team.

**Project Team Utilization of BIM**

Use of BIM across project teams adds value to projects, but requiring BIM experience is still not a common practice, especially for the construction team. **43% require design team members to have BIM experience, but only 21% require the same for construction team members.** However, a high percentage of those who do not require BIM expertise encourage it.

The advantages of having project team members who are experienced with BIM is evident from the high percentage who report project outcome and process benefits like **reduced conflicts and coordination problems during construction, reduced errors and omissions, better ability to maintain quality, and better design solutions.** Having team members with BIM experience also helps improve communication with 3D visualization. This report also includes details on the types of project team members with the greatest BIM experience on page 36.

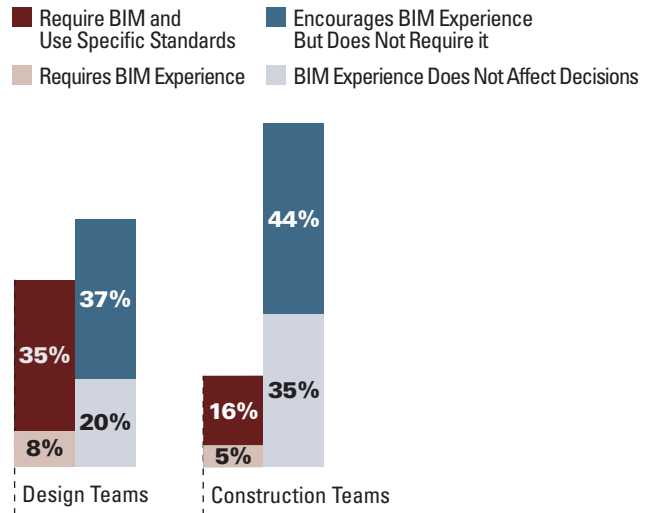
**BIM Return on Investment (ROI)**

**About two thirds of water sector engineers and contractors surveyed formally measure BIM ROI, but the majority is doing so on less than half of their projects. Reduced rework and improved project process outcomes** (such as fewer RFIs) are the factors that contribute most to BIM's ROI.

The top ongoing investments to support their use of BIM on water projects that they expect in the next few years are typical of a sector still early in its engagement with BIM. They include **BIM training, developing custom 3D libraries and developing collaborative procedures,** both within their companies and with other project team members.

**Requirements When Selecting Design and Construction Teams** (According to Those Involved in Selecting the Teams)

Dodge Data & Analytics, 2018



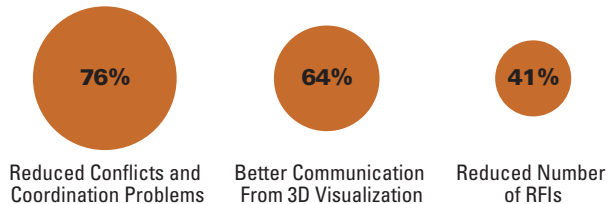
**Top Benefits Derived From BIM Use by Experienced Team Members** (Selected as One of the Top Three Benefits)

Dodge Data & Analytics, 2018

**Top Project Outcome Benefits**



**Top Process Benefits**





# Data: Introduction

Use of building information modeling (BIM) in the water sector is still emerging across the industry. Therefore, data from those who have used it on these projects provides critical insights about the potential benefits that BIM can provide to the sector as a whole.

This study examines the value of BIM reported by engineers, contractors and owners using BIM for water projects. Five case studies also augment the findings of the study, that the use of BIM promotes increased collaboration across the project team, enables owners to more effectively participate in the design stages of these facilities, improves design and is expected to contribute to the operation, maintenance and overall asset management programs for owners of water facilities.

The study findings are also considered throughout the analysis through the lens of other BIM studies conducted by Dodge Data & Analytics, in particular the transportation infrastructure study published in the *Business Value of BIM for Infrastructure 2017 SmartMarket Report*. Many of the findings from this study echo those of previous reports, including the value of BIM to support collaboration on projects, the importance of how it improves design, whose benefits cascade through the rest of the projects, and the critical benefit of having project team members experienced with BIM to fully derive the advantages of using this software and workflow.

However, there were a few findings that are also unique to the water sector, including the degree to which BIM use during design and construction is expected to support operations and maintenance, as well as overall asset management, for owners on water projects. The knowledge of various design team members is also unique to this sector, as is the degree to which they are formally evaluating the return on their investments in BIM.

The study findings also demonstrate that those using BIM on water projects expect to use it more, either on different types of water projects, or by increasing the intensity of it on specific types of projects, or both. All of these findings suggest that BIM is likely to become more common in the water sector in the future.

## Note About the Data

**The findings featured in this report are from an online study of engineers, contractors and owners using building information modeling (BIM) for projects in the water sector. The study was conducted from August 29, 2017 to January 23, 2018.**

**BIM use for the purposes of this study is defined as authoring models in BIM and/or analyzing or using models authored by others.**

**74 engineers, contractors and owners responded to the survey. Responses are primarily from companies in North America, but there are some responses from Europe and Asia as well. Most of the findings are reported for the entire survey group, but additional analysis is also done by type of company and by years of experience with BIM.**

**A more complete description of the study and the respondents, including a breakdown of the percentage of respondents by company type and by BIM experience, can be found in the Methodology on page 44.**

# Data: How BIM Is Being Used in the Water Sector

THE BUSINESS VALUE OF BIM FOR WATER PROJECTS DATA

## BIM Users in the Water Sector

The participants from the water sector in this study are profiled here in terms of their level of BIM implementation and BIM experience. The study is focused solely on BIM users, so only engineers and contractors who stated that they use BIM, and only owners whose project teams use BIM, could participate.

### How BIM Is Used

In this study, as in all Business Value of BIM studies conducted by Dodge Data & Analytics, use of BIM is defined as authoring models or the analysis of models used by other. **Nearly all engineers and contractors using BIM in the water sector author models, and over two thirds of those authoring models also analyze models created by others.**

### COMPARISON WITH TRANSPORTATION SECTOR

91% of water sector contractors author models, compared with 71% of transportation sector contractors, as reported in *The Business Value of BIM for Infrastructure 2017 SmartMarket Report*. One possible reason for this gap could be the proportion of very large contractors participating in the current study.

### BIM Implementation

Owners in the water sector are evenly split between those who report that BIM is used on less than half of their projects and those who report it is used on half or more.

### BIM Experience and Expertise

Respondents were asked how long they have worked with BIM on water projects and their degree of expertise, ranging from basic to expert, using the definitions listed in the chart at right. Expertise correlates closely to years of experience in their responses. The findings show that BIM maturity is still evolving in the water sector:

- **The highest percentage (41%) report that they have a moderate level of expertise.**
- **Only a small percentage identify themselves as basic users (15%) or expert users (12%).**

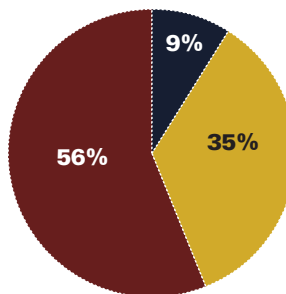
### COMPARISON WITH TRANSPORTATION SECTOR

A higher percentage of engineers (43%) and especially contractors (72%) in the water sector report that they have more than five years experience with BIM than those in the transportation sector (18% and 22%, respectively). Increasing work in transportation has led to influx of new users, but the water sector has not seen a similar increase in volume of work.

### How BIM Is Used (According to Engineers and Contractors)

Dodge Data & Analytics, 2018

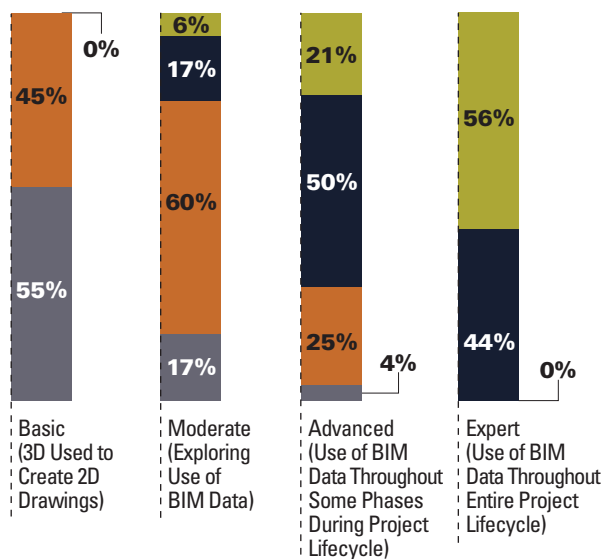
- Using Models Created by Others to Visualize Information
- Authoring BIM Models
- Authoring and Analyzing Models



### BIM Experience and Expertise (Years of Experience With BIM for Each Level of BIM Sophistication)

Dodge Data & Analytics, 2018

- 2 Years or Less
- 3 to 5 Years
- 6 to 10 Years
- More Than 10 Years



## Portrait of an Owner's BIM Journey

**San Francisco's Infrastructure Division is committed to the use of BIM on many of their projects, and they've learned a few lessons along the way as they have seen the value of BIM implementation on complicated projects.**

Owners of building projects are more likely to gain full benefits from BIM throughout the lifecycle of their projects if they are active partners in its use on projects. The Engineering Management Bureau in the Infrastructure Division of San Francisco's Public Utilities Commission is currently engaged in that process, and their first BIM project has recently received its notice to proceed to construction. Their BIM journey and the lessons they've learned can shed a light on the benefits and challenges owners experience when engaging with BIM.

### Starting to Use BIM

Johanna Wong, the manager of the Engineering Management Bureau in the infrastructure division, believes that to successfully launch a BIM program, it is critical to identify key projects where BIM offers "the biggest bang for your buck," because of the challenges of getting an organization started. "Do a little at a time because [BIM] is a big investment: time, money, resources." She compares it to "flying an airplane while fixing the airplane."

Garrett Low, division manager who works with Wong, concurs. "The challenge is, it takes longer than you might hope for. We had hoped for a faster transition in getting people up to speed and expertise."

They've dealt with this challenge

in different ways. First, they have worked with consultants, and they recommend bringing in a consultant as early as possible in the process. Wong says that the consultants are helping to "assist us in establishing our organization framework: our main goals as an organization, what BIM uses we should be focusing on ... the leadership who should be making decisions ... to make sure that we have the capability and capacity to deliver our BIM projects."

They also have been investing, not just in hardware and software, but in training. Out of a staff of over 80 people, they have focused on getting 15 to 20 people to truly understand BIM. In addition, Low also notes that they've been hiring people with BIM experience, bringing on a few specialists in areas like structural and electrical. "We are trying to use a different job description, and we are looking to staff differently than 10 years ago," he says.

### BIM Execution Plan

On projects identified as likely to benefit from the use of BIM, they create project-specific BIM execution plans. These include changes to their requirements during procurement, that not only inform companies that they will be provided with a BIM model, but that they are required to "update the model [and] populate the attribute database with details from materials and equipment that were installed." She also states that they have to use the model for submittals like their record drawings.

They also expect contractors to use the models for "visual presentation of their actual progress [during construction] compared with their scheduled progress."

However, they have a longer-term goal in mind. Wong says, "We want to create a template for a comprehensive BIM execution plan for our upcoming projects."

### BIM Benefits

Wong and Low report three main benefits from BIM use. The first is the ability to optimize the layout of their facilities, in terms of space restraints, facility needs and complex processes. The second, Wong explains, is "being able to present information to our stakeholders and operators, the users of the facility, so they have an easier way to grasp it, understand the information, comment on it, review it." The third is the ability to bring information on disparate systems, like structural models, electrical models, equipment details, etc., together into one location, that will help with clash detection during construction and be useful, says Wong, "all the way to the operation and maintenance of the facility."

While they don't know the exact use operations will have for their model, they are confident they will find it of value. According to Low, "We are turning over a pretty smart model with all the serial numbers and attributes." They envision operators accessing the model as needed on tablets as part of their work. ■

# Data: BIM Use

## for Water/Wastewater Projects

THE BUSINESS VALUE OF BIM FOR WATER PROJECTS DATA

### BIM Use on Types of Water/Wastewater Projects

#### BIM Use by Project Type

BIM is widely used across the water sector currently, but its use is not evenly distributed by project type. In order to better understand which types of water projects use BIM more frequently, engineers, contractors and owners who are involved in the five project types listed in the chart below were asked if they use BIM on those projects currently, or if they expect to use it in the next two years.

The findings demonstrate a strong increase in the use of BIM in the next two years across most project types, especially those with less current use of BIM.

- BIM is already widely used on water/wastewater treatment facilities (88%) and mining/industrial projects (79%), and within two years, nearly all (97%) of those working on these project types expect to use BIM on them.
- Approximately two thirds of respondents doing linear infrastructure projects (68%) are using BIM for those projects now, and another 20% expect to do so in the next two years.

- Over half of engineers, contractors and owners use BIM on their tunneling (58%) and hydroelectric (52%) projects, but the percentage not using it now who intend to do so in the next two years is relatively high for both of these project types (24% and 30%, respectively).

Since the respondents only include those who use BIM already, the high level of growth in BIM on project types where it is less commonly used now suggest that experience with BIM in one type of project leads to wider use in others.

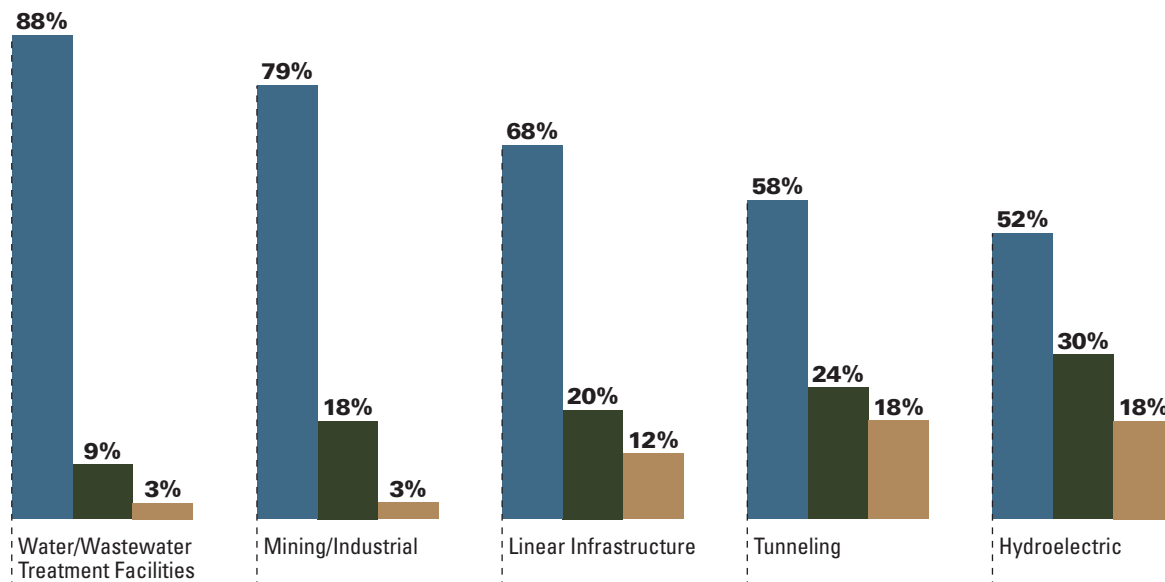
#### Intensity of BIM Use

Those using BIM on each project type were asked about the percentage of their projects of that type on which BIM is used now, and the percentage on which they expect it to be used within two years, and those with a high intensity of use (on more than 75% of their projects) are shown in the chart on page 11.

#### Use of BIM by Project Type (Current and Expected Future Use)

Dodge Data & Analytics, 2018

■ Currently Use BIM ■ Do Not Use BIM but Plan to Begin Within Two Years ■ Do Not Use BIM and Do Not Plan to Within the Next Two Years



- **Water/wastewater treatment facilities and mining/ industrial projects have the highest level of intensity of BIM use**, with nearly half (47% and 46%, respectively) of those using BIM on them reporting that they do so on most projects (more than 75%).
- **The percentage expecting to use BIM on water/ wastewater treatment facilities on most of their projects in the next two years increases dramatically to 61%.**
  - Only about one quarter of owners say that BIM will be used on this high percentage of their water/ wastewater treatment facilities. This suggests that among BIM users, the use on this project type will be nearly ubiquitous, but that the rest of the industry is still catching up. Therefore, BIM use may offer a competitive advantage, especially as owners seek to use the data generated by BIM for operations and maintenance, or for asset management.
- **The percentage expecting to use BIM on the majority of their mining/industrial projects in the next two years increases to 53%.** This is the smallest increase in intensity of any of the water project types, suggesting that, despite relatively high overall levels of use, BIM users in this sector may be facing challenges not seen in other sectors.
- **Use of BIM for linear infrastructure is also expected to intensify among respondents**, with only 34% using them on more than 75% of these projects now, but 57% expecting to do so within the next two years.
- **A similar pattern in terms of the increase in the percentage of contractors using BIM on tunneling and hydroelectric projects also occurs in the intensity of BIM use for these project types.** Intensity of use for each is relatively low now, but the percentage of respondents expecting to use BIM on more than 75% of their projects increases dramatically in the next two years

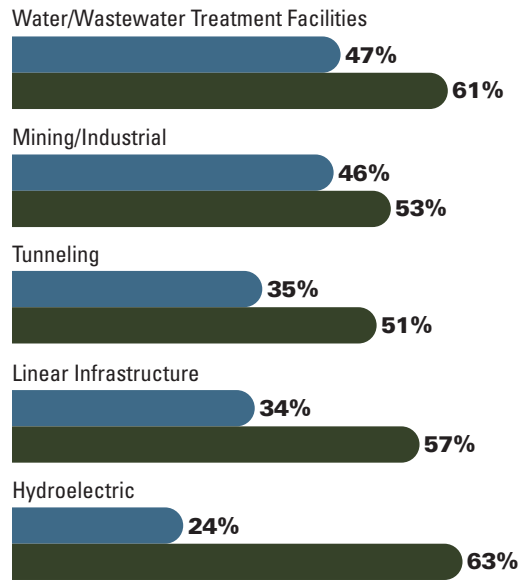
These findings demonstrate that experience with BIM for one type of water project not only leads to wider use on other types of projects, but also to greater intensity of BIM use for that type of project.

The benefits and advantages of using BIM, not just for engineers and contractors but also for owners in the operational phases of their assets, are no doubt driving this increased use, which also suggests that BIM use currently could provide a competitive advantage, and that eventually, not using BIM for these project types may make firms less competitive in the water sector.

**High Intensity BIM Use by Project Type**  
(According to Those Using BIM on Each Project Type)

Dodge Data & Analytics, 2018

- Currently Used on More Than 75% of Projects
- Expect to Use on More Than 75% of Projects in Two Years



## Most Frequent Project-Related BIM Activities

Engineers, contractors and owners were asked to select the three most common BIM activities that they engage in related to projects from a list of 12 possible activities. The chart at right indicates the activities selected among the top three by more than 10% of respondents.

### Common Activities Used by Most Respondents

The two most common project-related BIM activities are associated with design, suggesting that BIM is most widely deployed and actively used during the design phase of water projects.

■ **Creation of Bid/Construction Drawings: The highest percentage (72%) of engineers, architects and contractors rank creation of bid/construction drawings among their top three most common BIM activities.**

- An equal percentage of engineers and contractors (80%) report that this is one of their top three activities.
- Only about half of owners (47%) report that this is one of their top three activities, but it is still one of the most frequently selected items for them.

■ **Clash Detection/Avoidance: 70% of respondents rank clash detection as a top BIM activity.** Clash detection is frequently a top use for BIM, so this is consistent with findings from other Dodge studies on BIM value.

- A much higher percentage of engineers (90%) rank this as a top activity than do contractors (64%).
- This is also ranked by nearly half of owners (42%) as a common activity.

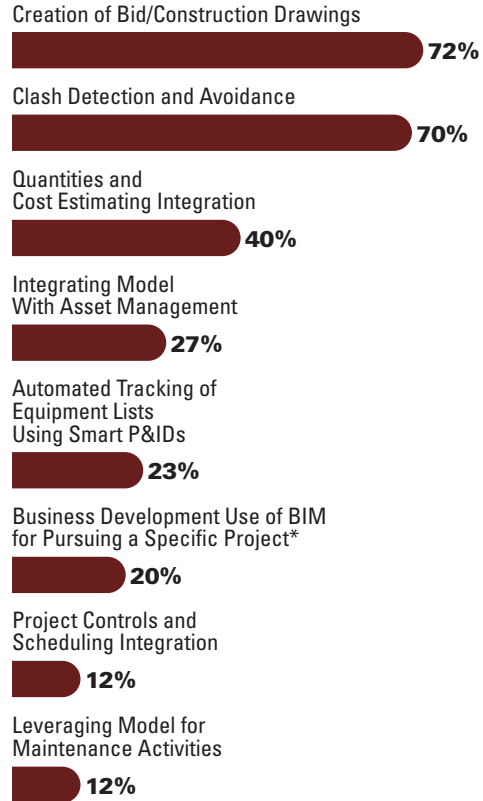
### Bidding/Cost Control Activities

In addition to the creation of bid drawings, one other bidding/cost control activity was included in the list respondents were asked to rank. **Just under half (40%) of respondents rank quantities and cost estimating integration among their top three activities.**

The percentage who consider it a top activity is relatively consistent across engineers, contractors and owners. This demonstrates the value seen in this activity, but also suggests that there is significant room for increased use of it.

### Project-Related BIM Activities Most Frequently Used

Dodge Data & Analytics, 2018



\*Engineers and Contractors Only

### Construction Activities

Several activities help with project management during construction, and they are ranked among the top activities in varying degrees.

- **The construction activity most commonly ranked in the top three is automated tracking of equipment lists using Smart P&IDs.** This activity is notable because it is valuable during both the construction and operational phase of the project. Therefore, it is not surprising that a similar percentage of engineers, contractors and owners rank this as a top activity.
- **All of the other construction activities are emerging uses, not commonly rated as top activities.** These include project controls and scheduling integration, ranked a top activity by 12%, and automated quality control practices, which is not included on the chart because it is ranked as a top practice by only 8%.

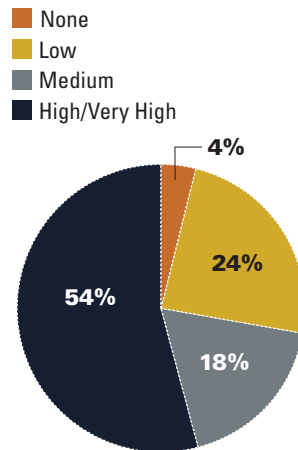
### Operational Activities

Many water sector practitioners are able to leverage the models during operations through multiple activities.

- **The most common operational activity is integrating the model with asset management, which over one quarter (27%) rank among their top three activities.** This emphasis on asset management is more pronounced in the water sector than in many other sector-focused studies on BIM conducted by Dodge. More information on the degree to which model integration with asset management occurs can be found on page 14.
- **As mentioned above, automated tracking of equipment lists using Smart P&IDs also occurs in the operational phase of the building, and is the second most highly ranked among the operational activities.**
- **Emerging activities that are currently not as highly ranked include leveraging the model for maintenance activities (12%), linking with analysis applications (9%), and integrating with performance monitors, sensors or smart devices (IoT) (4%).** Many of these are still at the early stages of adoption, and their importance in this sector will be interesting to track over time.

### Business Development Use of BIM for Pursuing a Specific Project (According to Engineers and Contractors)

Dodge Data & Analytics, 2018



### Business Development and Pursuit

Business development and pursuit support, which leverages a firm's BIM capability to specifically pursue a particular project (as opposed to general marketing of a company's overall BIM experience), is ranked by 20% of engineers and contractors as a top BIM activity. However, over half of engineers and contractors report their use of BIM for this activity at a high/very high level, as the chart at right indicates, suggesting that widespread use is relatively high, even if it does not often rank among the top three activities.

## BIM Use During Operations Phase

Engineers, contractors and owners were asked to characterize the use of BIM during the operations phase of their projects to assist with maintenance and to assist with asset management.

The use of models during the operational phase in the water sector is higher than that reported in other sectors on other Dodge research on the use of BIM.

### Asset Management

Most respondents (86%) report that the models from their projects are integrated with asset management systems. Over half (56%) state that this occurs at a medium to high/very high level on their projects.

The owners who stated that the models from their projects are integrated with asset management systems were asked for more information about the degree of integration they currently have. While the number of owners who responded was too low for anything other than a directional comparison, it is notable that they split nearly evenly between those at a relatively low level of integration—using the model as a visual aid in the asset management system—and those at a higher level of integration, who require models to be coded to their asset management system, and who import or link data from the model to the asset.

### Operations and Maintenance Activities

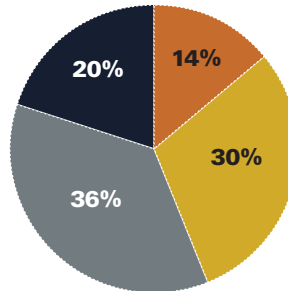
Most respondents (86%) also believe that models from their projects are being used to support operations and maintenance activities. However, the majority of those respondents characterize the use as relatively low (43% of the total respondents), confirming that owners are just beginning to implement models, and data from those models, into their operations and maintenance work.

### Use of BIM During the Operations Phase

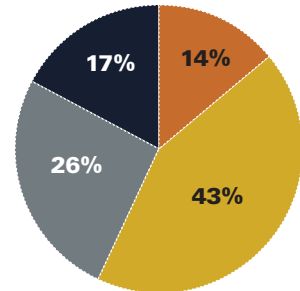
Dodge Data & Analytics, 2018

- None
- Low
- Medium
- High/Very High

Integrating the Model With Asset Management



Operations and Maintenance Activities





## BIM Meets Smart

**As the data management, analysis and decision-making encompassed by BIM and smart technologies increasingly overlap, the next step is to incorporate them both into a single system that generates even greater advantages.**

### Getting Smart

Smart infrastructure uses digital technology to enhance a physical asset. “When you connect the physical and the digital together, that’s the point at which you get additional value,” says Richard Shennan, formerly global practice leader for BIM at Mott MacDonald, and now the company’s digital business development director.

For example, sensors installed at critical points of a water or wastewater network, collecting real-time information on flow rates, water levels and pressures, can be combined with core asset information and performance data from BIM and GIS models, asset management systems, hydraulic models and external sources such as SCADA to generate a clearer picture of how the infrastructure is performing, identify anomalies requiring attention and optimize maintenance.

Smart systems can also assist with disaster recovery. Following the earthquake in 2011, the city of Christchurch, New Zealand, was able to use before-and-after data from a smart system—which it had incorporated into its wastewater infrastructure five years earlier—to identify and locate multiple ruptures, and to prioritize repairs according to data-based indicators of the level of damage.

To conceptualize a smart system, it may help to think of it as comprising three layers: data management, in

which data from multiple sources—including BIM—are harvested, cleaned up and structured; sense-making, in which value is added by using middleware, data mining and other analytics to make sense of the basic data; and decision-making, in which capacity, reliability, efficiency and resilience are improved based on the intelligence generated in the previous two layers. Communications bind these three layers together and connect the whole to the outside world.

### Twin Assets

Recently, awareness of the notion of a digital twin has burgeoned. A digital twin is a complete, dynamic virtual representation of an asset, a process or service. It combines in one place all of the information that is typically scattered among different formats and even different owners, and keeps them current—sometimes to the second.

A digital twin can generate value in two ways: indirectly through generating information that helps optimize an asset’s use, or directly through generating data that has trade value in its own right. International Data Corporation, a technology research and advisory firm, predicts that by 2020, 30% of Forbes Global 2000 companies will be using data from digital twins to achieve gains of up to 25% through improved product innovation success rates and organizational productivity.

### The Value for Infrastructure

In the infrastructure sector, the fundamental promise of smart technologies is “more from what you’ve got,” says Shennan. There’s still scope for innovation in designing and delivering new assets, he says, but the real gains will come from applying smart technologies to existing infrastructure—just because there’s so much more of it. Over 90% of the infrastructure that will be in operation 25 years from now has already been built.

The city of Auckland, New Zealand, has achieved cost savings of over 20% through efficiency gains from applying a smart system to its existing stormwater infrastructure. And in some cases, leveraging data to improve existing water infrastructure could achieve capacity improvements of up to 40% without building, according to an industry publication.

Whether existing infrastructure is retrofitted with smart systems, or new construction integrates them from the outset, a comprehensive and well-thought-out BIM strategy can contribute. BIM can provide the foundation for a lifecycle asset management system that enables real-time performance optimization, proactive maintenance, targeted investment in asset improvement and enhanced resilience: in other words, smart infrastructure. ■

# Pioneering BIM For Lifecycle Operations

## Biological Nutrient Removal Facility at the EchoWater Project

ELK GROVE, CALIFORNIA

The EchoWater Project, a \$1.75 billion upgrade to Sacramento Regional County Sanitation District (Regional San)'s wastewater treatment plant, is one of the largest public works projects in the region's history. When complete, by 2023, the project will treat wastewater to new standards for discharge into the Sacramento River: improving water quality in the river, protecting the fragile river delta ecosystem, expanding opportunities for recycled water use and assuring plant capabilities well into the future. One of the components now under construction, the \$600 million, 20-acre biological nutrient removal (BNR) facility, exemplifies how the EchoWater Project is using BIM, from predesign through asset management, to leverage project information into a more effective enterprise.

"Any time I see some data," says Greg Sturges, BIM technology leader with EchoWater's Program

Management Office (PMO), "I ask, 'How can I leverage that?'" While maintaining a clear focus on the main priority—"it's all about getting it built"—Sturges confesses to being something of a BIM evangelist. As a result, EchoWater is pioneering innovative and comprehensive uses for BIM for the project's lifecycle.

### 3D Design

The BNR designers worked in 3D from the outset, which facilitated communication among the design disciplines, and helped with early and ongoing detection of clashes. Making changes and improvements in the model resulted in fewer drawing iterations, and generating the BNR's 2,600 drawings directly from the model was simpler than drafting each one individually, with reduced opportunities for conflicts and errors.

One of the most powerful benefits of this mode of working, however, was the ability to communicate more effectively with stakeholders outside the design team. In workshops

with operations and maintenance (O&M) staff, who are not always familiar with technical drawings, the design team used the model to provide virtual reality walkthroughs. Understanding how pumps, walkways and valves were being located, for example, enabled O&M staff to make recommendations for improved functionality and buy in to the design direction. "BIM helped us explain the work," says Jim Clark, senior vice president at Black & Veatch, design consultants for the BNR. "I can't emphasize enough how valuable that is."

BIM also facilitated iterative cost estimates during the design process. Quantity takeoffs from a model that has been properly set up are easier and more accurate than measuring pipe lengths and counting valves on 2D drawings, with the result that "our cost estimate was right in the middle of the bids," says Clark. And now that construction is underway, the ability to link invoicing software to the model is enabling the PMO to provide improved accountability for Regional San. "At any date, we know what we've spent," says Sturges.

### Facilitating Construction

In a way, the BNR is being built not once, but repeatedly until it is right. BIM-based construction process visualizations are helping the project team to identify and resolve issues before work onsite starts, reducing risks for all parties. During the transition from design to construction, for example, in addition to issuing a conventional bid set of drawings, the PMO invited contractors to view a BIM-based animation, complete with a



The Biological Nutrient Removal Facility at EchoWater is using BIM in pioneering ways across the project lifecycle.

## Biological Nutrient Removal Facility at the EchoWater Project

ELK GROVE, CALIFORNIA

construction simulation showing expenditures per day, to help them better understand the scope of work in advance of their bids. And with construction in progress, the project team continues to use BIM to rehearse all facets of a job—locating a crane on a tight site, for example—before executing it in the field.

In fact, the first time the project ran a construction simulation, using a virtual design and construction add-on with integrated scheduling, the initial minute and a half revealed three significant issues: a constructability problem, a schedule break and insufficient granularity in the schedule content.

With scheduling integrated into the model, monitoring the progress of construction can be as simple as comparing a site photograph and the model view of the same date. More precise information is reported by the contractor turning on indicators in the model as components complete. This speeds up construction schedule reviews, and flags schedule issues before they become problems in the field.

Work that is completed onsite differently from what the model describes is reported to the designers, who then revise the model and issue an updated version to the PMO every 30 days. This process maintains the ongoing accuracy of the model, improving its utility and enhancing project continuity.

### Lifecycle Operations and Asset Management

Beyond design and construction, one of the BNR project's most innovative uses of BIM is the extraction of data from the model to support asset management.

The project team has developed and implemented automated methods for tagging asset data and project documentation generated during design, construction and commissioning, and migrating it into Regional San's computerized maintenance management system. Automated data migration significantly reduces the workload compared with manual data collection and file indexing.

For example, each piece of equipment has a unique identifying number that links to data classifying the asset according to category, size and type. The tagging also indicates in which views and on which sheets the assets to which the identifiers refer appear. Once that information is migrated to the client's system, it can be easily supplemented with more data—such as submittals, cut sheets, drawings, and process and instrumentation diagrams. The information will inform Regional San's maintenance planning and tracking, and provide O&M staff with a complete picture of each component before they go out and start working on it. "Our data migration solution and workflows are about leveraging the information that already exists, and supplementing it, to efficiently operate and maintain the facilities from the moment we hand over the project to Regional San," says Sturges.

To streamline interfaces over the course of what will be a decade-long endeavour, the PMO has established BIM standards for use projectwide; it also provides oversight and mentoring to BIM designers throughout the project. Predictably for a sector where BIM is still gaining traction, not everyone

on the project is equally fluent with the technology, and Sturges reports having to pump the brakes a few times to allow people with different levels of understanding and talent to catch up. Nonetheless, he says, "the EchoWater BIM solution is powerful, effective and wide open," and he sees it returning benefits across the entire spectrum of users and the full lifecycle of the project. ■

### Project Facts and Figures

#### Budget

\$1.75 billion (EchoWater Project); \$600 million (BNR)

#### Construction Start (BNR)

2016

#### Construction Completion (BNR)

2020

#### Owner

Sacramento Regional County Sanitation District

#### Program Management

Integrated team of Sacramento Regional County Sanitation District staff and program management consultants (Joint Venture with Brown and Caldwell and HDR) serving as an extension of staff under the direction of the Regional San EchoWater Project Program Manager

#### Design Engineers

Black & Veatch (BNR); CH2M (Primary Effluent Pumping Station (PEPS))

#### Engineering Contractor

Dragados USA (BNR/PEPS)

#### Construction Management Services

Jacobs, Psomas, Covello in joint venture

stats

# Data: BIM Benefits

THE BUSINESS VALUE OF BIM FOR WATER PROJECTS DATA

## Top Business Impacts of BIM Use

Dodge studies on the value of BIM since 2006 have consistently demonstrated business benefits from its use, and more recent sector-focused studies reveal key differences in which impacts are most significant.

Engineers and contractors were asked to identify the top three positive impacts on their businesses attributable to using BIM on water projects from a list of eight potential ones. The chart at right shows those selected by the highest percentage of engineers and contractors, demonstrating the unique value that BIM brings to businesses in the water sector. Interestingly, there are no significant differences by level of experience or by type of company in the reporting of these benefits.

### Collaboration

The top business benefit reported is the way in which BIM supports the ability to work collaboratively with other project team companies. While collaboration is always highly valued in other BIM studies conducted by Dodge, its clear top ranking in this case demonstrates the degree to which it is positively impacting the water sector.

### Client Satisfaction and Relationships

The second most frequently selected top business benefit of BIM is increased client satisfaction. This is directly related to the project benefits that BIM provides (see page 20), including better cost control (a top project benefit for contractors), higher quality projects and the ability to provide better design solutions because of BIM.

However, at this point, the benefits BIM provides to relationships with existing clients is clearly felt on a project by project basis. Only 5% of respondents select maintaining repeat business with existing clients as a top benefit of using BIM. While it is important to note that this does not reflect all those who experience this benefit, only those who consider it one of the top three, it still suggests that using BIM does not necessarily influence their ability to work again with the same client. This may in part be due to the prevalence of public work in the water sector, and the fact that it is a formal bidding process, rather than client relationships, that determines how work is awarded.

## Top Business Impacts of BIM Use (According to Engineers and Contractors)

Dodge Data & Analytics, 2018



**Growing the Business**

The findings demonstrate that a notable percentage of contractors feel that one of the top benefits of BIM is its contribution to business growth.

- **One third (33%) say that a top benefit of their use of BIM is the way its supports their ability to offer new services.** Offering new services allows not only for growth, but it also increases the stability of a company’s position, allowing them to pivot as the market changes to pursue the best projects or enter new markets.
- **Nearly one third (31%) also find that BIM helps them to market new business to new clients.** *Dodge Outlook* data makes clear that the dollar value of project starts in the US water sector has not yet returned to pre-recession levels, so engineers and contractors need every competitive advantage they can leverage to pursue a limited amount of new work. Therefore, it is not surprising that nearly one third report their BIM capabilities are making a strong contribution to those efforts.

**Company Reputation**

**Another top BIM benefit reported by over one third of engineers and contractors is how BIM capability enhances their company’s reputation.** While this study only included respondents using BIM, some findings, such as the owner estimation of the percentage of their projects on which BIM is used, suggest that BIM is still on its way to becoming a common practice in this industry. Therefore, use of this technology, and its ensuing project benefits (see page 20), can still serve to distinguish a company from their competitors. However, it is likely that the water sector will soon see a shift, where BIM use is essential to remain competitive, similar to how that is already occurring in other markets.

**STAFF RECRUITMENT/RETENTION**

BIM can impact recruiting, not just through a company’s reputation, but also by making the company more appealing to a younger, more tech-savvy demographic. **However, only 11% of engineers and contractors currently report that staff recruitment/retention is a top benefit of using BIM.** This is in sharp contrast to the findings from the *Business Value of BIM for Infrastructure SmartMarket Report*, where 43% of respondents in the transportation sector rated it as high/very high.

This finding may again reflect the influence of the somewhat flat water market over the last few years. Given the infrastructure needs in the water sector that have widely been identified, the focus on water projects due to the impacts of recent natural disasters and the potential for increased infrastructure funding, it is possible that this market may see an increase in activity. This could lead the water sector to experience the same challenges in finding skilled workers that are currently being experienced in the commercial market, and could lead to increasing the importance of this benefit to engineers and contractors in the long run.

**Increased Profits**

Only a few companies (5%) consider increased profits due to their use of BIM to be a top business benefit. In a competitive market, owners may ultimately see more benefit from improved project performance than engineers or contractors. More contractors (32%) do report improved cost control as a top project benefit (see page 20), which helps them retain their margins rather than increasing their profitability.

This benefit is more widely reported in Dodge studies on the business value of BIM in sectors where BIM use is more mature, such as the vertical buildings sector. Thus, it is likely that more engineers and contractors in the water sector will report this benefit as BIM adoption and implementation advance in this sector.

## Top Project Benefits of BIM Use

Unlike the business benefits, which were asked only of engineers and contractors, all respondents, including owners, were asked to select their top three project benefits from a list of 12 options. While owners may not use BIM directly, they often directly benefit from the advantages created on projects from BIM use by their project teams.

The benefits fall into four categories: Better Design, Better Project Outcomes, Construction Benefits and Process Improvements.

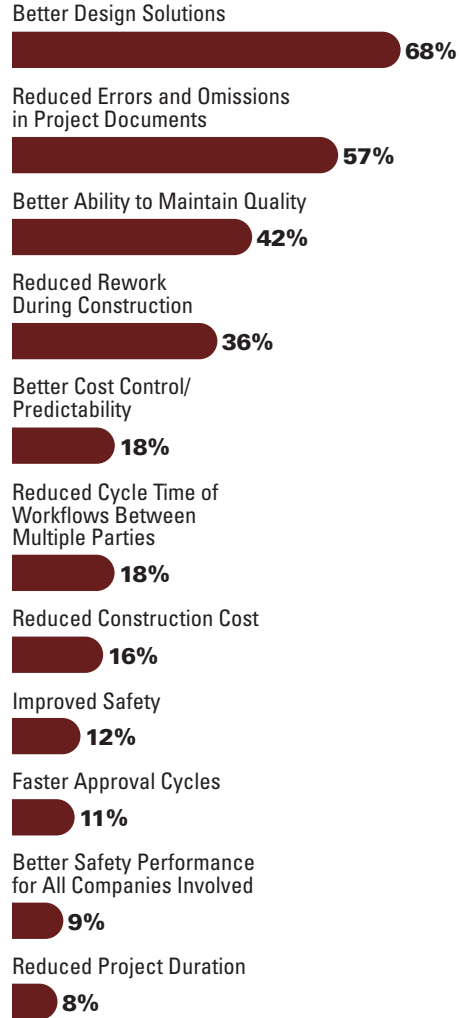
### Better Design

The two project benefits ranked most frequently in their top three by respondents both relate to better design and documentation. This makes sense since these benefits cascade down through the rest of the project lifecycle.

- **By far, the benefit most frequently ranked among the top three is better design solutions.** Use of BIM tools can yield a more well-reasoned design, informed by analysis and simulation, that can more effectively achieve project goals. This can encourage more innovation on projects, as well as save time and costs. Gaining a reputation for better design can also help firms be more competitive.
- **Reduced errors and omissions is also considered a top benefit by over half of all respondents.** More engineers (70%) than contractors (36%) regard this as one of the top benefits. Fewer errors and omissions can help reduce RFIs and change orders, eliminating potential schedule delays and cost overruns.

### Top Project Benefits of BIM Use (According to All Respondents)

Dodge Data & Analytics, 2018



### Better Project Outcomes

**Another top project benefit of BIM is that it helps respondents to maintain project quality.** Certainly, the better design-related elements cited above directly impact the ability to improve quality, especially the ability to determine better design solutions. Quality is one of three top factors by which owners gauge project success, and this finding is likely to support the business outcome of more satisfied clients reported by nearly half (45%) of engineers and contractors (see page 18).

**Almost one fifth (18%) also rank better cost control/predictability as a top three benefit, including nearly one third (31%) of contractors.** Contractors are often highly impacted by cost changes or overruns, so it is not surprising that this benefit carries particular weight with them, and it aligns with the associated benefit of reduced construction cost.

**Far fewer respondents (8%) select reduced project duration as a top benefit.** On water projects there may not be as high a value assigned to accelerated completion as in the commercial or institutional sectors. The ability to achieve cost and quality control are thus prioritized by many respondents over the ability to shorten project duration.

### Construction Benefits

In addition to improving design, the use of BIM also has a positive impact on construction issues.

- **Leading the list is reduced rework during construction, which is considered a top benefit by over one third (36%) of respondents.** Improved design could contribute to this, and certainly, clash detection has been demonstrated to significantly reduce rework, which ultimately helps to improve jobsite efficiency.
- **While only 12% report improved safety as a top benefit on water projects, that percentage may increase as BIM experience grows in this sector.** The *Safety Management in the Construction Industry 2017 SmartMarket Report* reveals that 69% of contractors (including those doing vertical construction) who use BIM see a positive impact on safety from that use. This is an increase of 27 percentage points over findings from a previous study in 2012, suggesting that in the overall industry, more BIM experience has led to a better understanding of how BIM can positively impact safety onsite. Since the water industry is still growing in its sophistication of BIM use (see page 10 and 11), it is likely that more respondents will be able to recognize and take advantage of the opportunities BIM offers to improve safety onsite in the future.

### Process Improvements

The final set of project benefits included in the study are process improvements. Only a small percentage of respondents selected any of these individual improvements among their top three benefits.

- **The top process improvement is reduced cycle time of workflows between multiple parties.** This process improvement is just one way in which BIM supports the ability of teams to work together. This leads to better, more efficient projects.
- **Faster approval cycles was selected by 11% as one of the top project benefits.** While the percentage is relatively low, the fact that it would be considered one of the top three benefits by even a small percentage suggests how important approval cycles can be to improving the flow of work on a project.

# Top Industry Factors

## That Would Increase the Benefits of BIM in the Water Sector

Engineers, contractors and owners were asked to select the three factors that would do the most to increase the benefits they can derive from using BIM on water projects. The industry factors fall into five categories: Improved BIM Software/Tools, Better BIM Skills (Among Users), More Widely Accepted BIM Standards, Owners Encouraging the Use of BIM and More Hard Data Demonstrating the Value of BIM.

Each of these categories will be examined below, but it is worth noting that the respondents are relatively evenly distributed among many of these factors, unlike similar questions discussed previously where respondents were asked to select the top three from a longer list (see pages 12, 18 and 20). In this case, no single factor exceeds 43%, and half fall between 40% and 20% of respondents. This suggests that many industry factors have the potential to influence the ability of companies to benefit from BIM, and that efforts to increase benefits across the industry must address multiple areas.

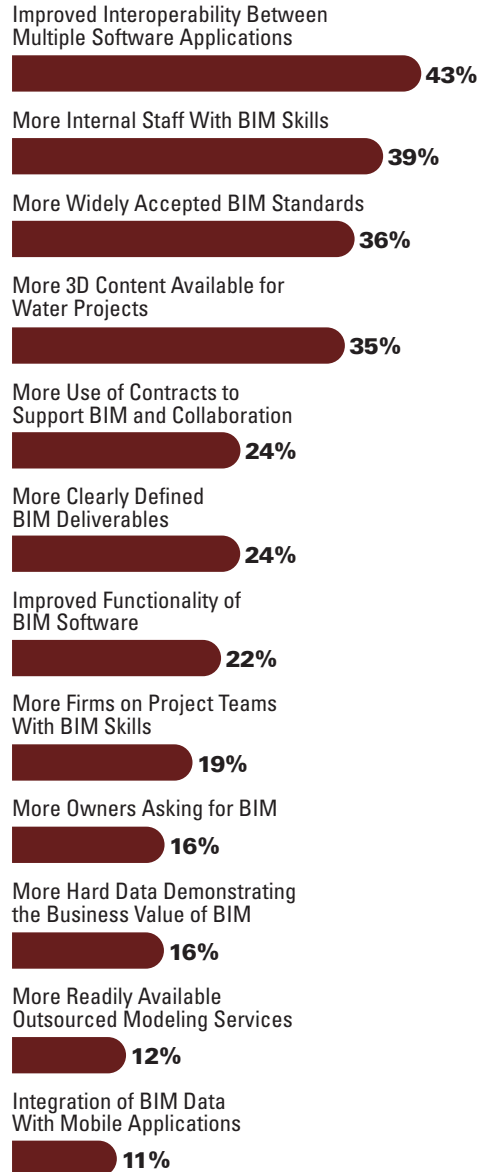
### Improved BIM Software/Tools

The findings demonstrate that improving BIM software and tools, including making them more applicable for the water sector, would help increase the effectiveness of BIM for the respondents, with two of the top factors most frequently selected belonging to this category.

- **Improved interoperability between multiple software applications is the most frequently selected factor, chosen by 43%.** This may be influenced by the strong interest in using models and BIM data during the operational phase for asset management and other purposes, which still presents challenges due to the variety of software used for design, construction and operations.
  - **Nearly two thirds (61%) of highly experienced BIM users (five or more years) believe that improved interoperability is one of the top factors that would help them achieve greater benefits from their BIM use,** which suggests that this would support more advanced uses of BIM.
- **Over one third of respondents (35%) regard more 3D content for water projects to be a critical factor in their ability to enhance the benefits they receive from using BIM.** The water sector has unique needs, and content specifically devised for this sector would help improve the ability to get the most from BIM for respondents.

### Top Industry Factors That Would Increase the Benefits of BIM

Dodge Data & Analytics, 2018





- **A moderately high percentage of respondents (22%) find that improved functionality of BIM software would enhance their ability to get more from BIM.** Again, it is likely that more functionality specifically geared toward the challenges of the water sector would be critical here. See the article on the use of BIM for design-to-fabrication on water projects on page 39 for an example of the challenges posed specifically for water sector projects in the use of BIM.
- **Only 11% currently select the ability to integrate BIM data with mobile devices as one of their top three factors to improve benefits.** This is not surprising, given the attention on more fundamental issues such as interoperability, sector-appropriate 3D content and improved BIM software functionality.

**Better BIM Skills**

BIM skills are also an issue in the water sector, and increasing skills among its users would help every company to better capitalize on the benefits available from using BIM.

- **39% select more internal staff with BIM skills as a top three factor for increasing the benefits they experience from BIM, which ranks this second among all the industry factors included in the study.** There was no significant difference in response between engineers and contractors on this point, or between those with more BIM experience and those with less, which suggests that this is an overall industry problem.
- **Nearly one fifth of respondents (19%) also find that more BIM skills at other companies that are part of the project team would also be important to increase BIM benefits.** With so many regarding their internal gaps as influential, it is not surprising that fewer rank the skills at other firms in their top three. As BIM use becomes more prevalent among some companies, this could increase in importance over time.
- **Only 12% regard having more readily available outsourced modeling services to be a top factor that would increase the benefits they see from BIM.** Most would clearly prefer more internal expertise than to seek it from other companies.

**BIM Standards**

More widely accepted BIM standards is also an important factor that would help improve the benefits of BIM, according to 36% of respondents. A widely accepted BIM standard would aid collaboration across the project team, and could also help improve the ability of owners to capitalize on BIM in the operations stage.

**Owner Influence on Use of BIM**

Only a small percentage of respondents (16%) believe that more owners asking for BIM would have a direct positive impact on its benefits. However, there are other higher scoring factors that owners can influence—such as the use of contracts that support BIM (24%) and more clearly defined BIM deliverables (24%)—so there are multiple ways that owners can help drive BIM and enhance its benefits to users.

**More Hard Data Demonstrating the Value of BIM**

While only 16% of all respondents consider this factor influential in the benefits they can achieve, there are notable differences by type of firm and years of experience with BIM.

- Over one third of owners (37%) think that having more hard data demonstrating BIM benefits would increase their benefits, compared with 13% of engineers and 4% of contractors.
- Nearly one quarter (24%) of those with five years or less of BIM experience select more data as one of the top factors allowing them to achieve stronger BIM benefits, compared with 6% of those with more BIM experience.

# Transition to BIM

## Southeast Water Treatment Plant

GUNTERSVILLE LAKE, ALABAMA

**H**untsville Utilities' new Southeast Water Treatment Plant at Gunterville Lake, in northern Alabama, looks so much like the renderings generated from the project's BIM model that John Toomey, design manager at Tetra Tech Inc., engineer for the project, calls it uncanny. "If you look at the construction photos and you look at what we drew," he says, "they're identical."

In addition to the project's remarkable fidelity to its designers' intentions, BIM facilitated numerous other benefits to the project. These include improved collaboration and stakeholder review, increased confidence around budget and buildability, a more accurate drawing set with reduced RFIs and change orders (a project total of two change orders, both pertaining to owner-added scope), completion almost a year ahead of schedule, and savings that let the owner add \$5 million in value and still spend \$10 million less than initial estimates.

The \$90 million surface water treatment plant is Huntsville's third, completed in the summer of 2017 to meet increasing demand from the fast-growing city. The facility comprises a raw water intake structure, conventional surface water treatment facilities with disinfection byproducts control, onsite residuals management facilities, and a laboratory and administration building. Ancillary infrastructure includes clear well and high service pumping facilities, three and a half miles of raw water transmission mains, and seven and a half miles of finished water transmission mains. The plant provides an initial capacity

of 24 million gallons per day (MGD), expandable to 96 MGD with total buildout of the masterplan.

### A Construction Boon

The completed project's uncanny resemblance to its BIM model is due in significant part to the enhanced visualization capability BIM provided to the construction team, a capacity Tony Stephens, operations manager at contractor Brasfield & Gorrie, calls invaluable. "We used it constantly throughout the project," he says, and while not every subcontractor or vendor is fluent with BIM, Stephens is seeing increasing use of apps that at least enable viewing of the model on an iPad.

Stephens credits the Southeast WTP's BIM model with speeding the construction team's initial uptake of the design. "We typically have to spend a good deal of time to study the set of 2D contract documents—split into multiple disciplines—and build the project in our minds," he says. BIM, by contrast, provided contractors with a pre-built visualization. It allowed them to peel back roofs and examine overhead structural and mechanical components, roll the building over and study under-slab components, and walk through the entire project prior to ever opening a set of 2D prints.

Experiencing the project visually and spatially through BIM also improved recollection and recognition during the course of construction, says Stephens, helping to reduce errors. Some trades even printed off screen shots from the model, and pinned them to the wall for reference as they worked. Pipe fitters assembling small chemical

feed lines, for example, appreciated the fully worked-through layouts that the designers' work in BIM provided. "We created everything as accurately as possible," says Jon Evans, BIM production manager at Tetra Tech, "so that we would have confidence that if we could build it in a 3D environment, the contractor could build that same thing in the real world."

The enhanced visualization that proved so helpful during construction also facilitated more meaningful conversations with user groups around issues such as access and maintenance, leading to refinements that improved the functionality of the design.

### Shifting to BIM

The Southeast WTP was one of a triad of concurrent projects with which Tetra Tech made its first foray into 3D design. The shift began paying off almost as soon as design got under way, but implementing the change took time and effort up front, and entailed myriad small and large decisions.

For example, an initial logistical decision was needed about the setup that would optimize the design team's workflow. Should there be servers in each office? An external server? Tetra Tech ultimately settled on a product that provided cloud-based access to the project for all team members, and Evans reports significantly reduced download and sync times compared with the firm's early experience with the alternatives.

The need to create content not provided by the software presented a preliminary challenge. The structural and architectural consultants were

CONTINUED

## Southeast Water Treatment Plant GUNTERSVILLE LAKE, ALABAMA



Rendering generated in BIM of the Southeast Water Treatment Plant.

already working with BIM, so even though other software designed for plant construction might have been a better fit for the project type, the team judged that the coordination advantages of working in a single environment justified the significant effort of creating infrastructure-specific content that their BIM software didn't provide.

Achieving a consistent look for the entire drawing set also entailed some setup. The site's civil engineering and yard piping was modeled in 3D software, and a few drawing set elements, such as general notes, detail sheets, hydraulic profiles, and piping and instrumentation diagrams, were produced in 2D. To make sure that the drawing set looked consistent regardless of which program was used to generate a particular sheet, Tetra Tech's production technicians transferred the firm's text, dimensions, symbols and formatting standards from 2D to BIM before starting the substantive work.

From a drafting perspective, the ease with which multiple views can be created from the model, and the

reduced opportunity for error in cutting those views from a single source (rather than updating multiple independently generated drawings), is BIM's single most significant contribution to increased efficiency and accuracy. Evans says: "Once we learned the program and how to apply it to our projects, it ended up being actually faster to put out a better quality plan set."

From a design perspective, Toomey cites the value of coordinating multiple disciplines' work and resolving conflicts through an iterative process within a single model. Design development in 3D also included plugging in components from different manufacturers to ensure that the design could accommodate the alternates encompassed by the project's specifications. And the data attached to components in the model, which can be exported to spreadsheets for ease of use during procurement, provides additional value.

For the Southeast WTP, these advantages culminated in an almost seamless design-to-construction

transition for which Stephens, Toomey and Evans credit BIM. "It's really all right there in that one little realm," says Stephens—which may be why, comparing one to the other, the resemblance is uncanny. ■

### Project Facts and Figures

stats

**Client/Owner**  
Huntsville Utilities

**Project Type**  
Surface water treatment plant

**Construction Cost**  
\$90 million

**Design Duration**  
2010 to 08/2014

**Construction Duration**  
04/215 to 08/2017

**Site Area**  
266 acres

**Plan Capacity**  
24 MGD, expandable to 96 MGD

**Design Engineer**  
Tetra Tech

**General Contractor**  
Brasfield & Gorrie

**Piping System Subcontractor**  
Garney Construction

## Integrating BIM and GIS Data

**Improvements in interoperability are essential to realize the full potential of GIS and BIM data integration for the construction industry.**

The push for initiatives such as Smart Cities and the use of the Internet of Things solutions has accelerated the rising need for “big data” analysis among some planners and BIM users, but long-standing issues of interoperability remain.

### Challenges

Weston Tanner, director of construction technology at Walsh Group, views BIM and GIS as “two separate worlds” that are struggling to coexist. “There needs to be more integration of those two worlds to get more value out of the technology,” he says.

At this point, he says users have to “dumb down” information to get it to work well together. “We end up creating workarounds,” he says. “So, you dumb down one piece of information or another. BIM on its own is really smart and GIS on its own is smart, but combined you have to let that stuff go.”

### Potential

Raj Prasad, chief technology officer at HDR, says his firm sees BIM and GIS integration as a critical part of leveraging 6D for BIM, helping owners and operators with asset/facilities management. “We look at BIM as building information management, not just modeling,” he says. “It’s truly taking that data from the time that we start any sort of conceptual design, all the way to handing it off to the owner for operations and maintenance. If you think about 6D [including project

lifecycle information], GIS becomes a significant piece of that puzzle. For us, what will allow our clients make the most informed decisions a lot quicker? We believe that’s where the nexus of BIM and GIS will be. For anything we do, there is a location-based analysis that occurs in order to provide that complete service.”

Mike Johnson, director of professional services, water, at HDR, says he sees the potential for data analysis to range from a Google Earth image of the planet down to a single connection on a plant. “For HDR and our clients, that opens up huge possibilities,” he adds.

At the project level, Johnson says HDR looks to leverage GIS data from “outside the fence” with BIM data “inside the fence.”

“If we design a concrete arch dam, we need to analyze that on a seismic basis,” he says. “You take the GIS data in terms of topology, and you want to fuse that with the actual design dimensions of the arch dam, so you can run the seismic data that is square miles in terms of extent.”

Johnson notes that the ability to merge large collections of data has only been possible in recent years. “The natural evolution of the industry is that we’re now able to process and handle terabytes of data, which before was unheard of,” he adds.

Still, the process can be very time consuming. “It could take a day to model and 24 hours to process to get the end result,” Prasad says. “If we made a mistake, that’s another 24 hours.”

### Need for Reliable Data Exchange

Potential productivity loss is a main reason why Prasad and Johnson say it is critical to get reliable information exchange between BIM and GIS. Johnson notes that one major issue that his team deals with is translating coordinate systems between BIM and GIS models.

“If you don’t watch what you’re doing in terms of the GIS data and then really understand how that translates to the coordinate system that the dam was designed in ... you have a problem. All of a sudden, things are off by four feet, and everyone is scratching their heads,” he says.

Generally, design teams can find ways to overcome these issues, Prasad says. However, software vendors need to find ways to make these translations and exchanges easier and more reliable. Interoperability issues hamper adoption, he notes, but as demand for better integration of BIM and GIS data rises, he says software vendors will be forced to find solutions.

“I look at the interoperability issues that exist today from a maturity model standpoint,” he says. “All of these vendors to date have been quite siloed, but they understand that those days are coming to an end rapidly.” ■

# Data: BIM ROI

THE BUSINESS VALUE OF BIM FOR WATER PROJECTS DATA

## Formal Measurement of BIM ROI

Many companies in the water sector seek to understand the return on investment they gain from employing BIM.

### Engineers and Contractors

**Two thirds (67%) of engineers and contractors formally measure BIM on at least some of their projects.** However, most of them do so on fewer than half of the projects on which they are using BIM. Only 11%, in fact, do so on the majority (over 75%) of their projects.

There are no significant differences between engineers and contractors in terms of how frequently they formally measure BIM ROI on their water projects.

### COMPARISON WITH TRANSPORTATION SECTOR

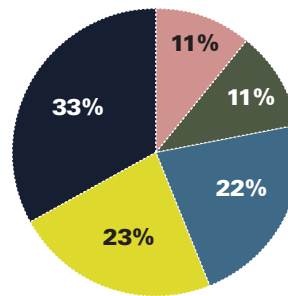
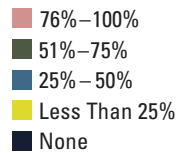
At least some formal measurement of ROI is even more common in the transportation sector. **Nearly all (90%) of the engineers in that sector formally measure BIM on at least some of their projects, and 80% of contractors do as well, compared with 70% and 64% in the water sector, respectively.** One factor that likely contributes to the lower percentage of respondents in the water sector formally measuring ROI on BIM is that they have generally been using BIM longer than the respondents from the transportation infrastructure BIM study, and therefore have a better sense of its value.

### Owners

Owners in the water sector were also asked about the degree to which they formally measure the ROI of BIM use. However, since they are not frequently investing in or paying directly for the cost of BIM themselves, formal measurement of BIM ROI is less common among owners than among engineers and contractors, with only about one fifth reporting that they do formal measurements at all, and none reporting that they measure BIM ROI on more than one quarter of their projects.

### Percentage of Water Projects on Which BIM ROI Is Formally Measured (According to Engineers and Contractors)

Dodge Data & Analytics, 2018



## Most Important Factors Determining ROI for BIM Use on Water Projects

The engineers, contractors and owners who formally measure the ROI they achieve from BIM on water projects (see page 27) selected the top three factors that they use to determine BIM ROI from a list of 14 potential factors. The chart at right indicates all selected by 10% of respondents or more among their top three.

The factors provided in the study fall into four major categories: Process and Productivity Improvements, Quality and Design, Improved Project Performance and Increased Profitability.

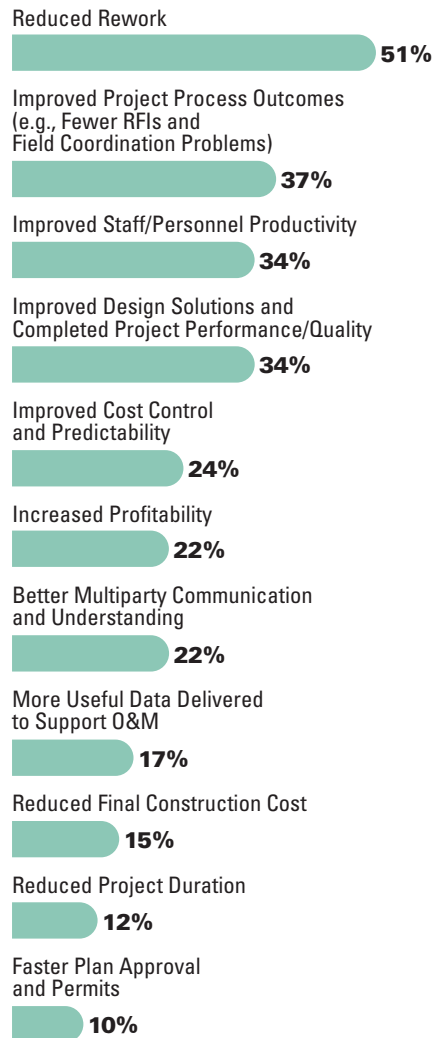
### Process and Productivity Improvements

The three top factors selected by the highest percentage of those formally tracking ROI involve process and productivity improvements.

- **Reduced rework is the top factor, the only one selected by over half of respondents (51%).** Reducing rework can save time, keep a project on schedule, help to more effectively manage workforce onsite and help make projects safer. It is therefore not surprising that so many rank it among the top three factors that help determine the ROI from their use of BIM on water projects.
- **Improved project process outcomes is ranked in the top three by the second highest percentage of respondents,** demonstrating the importance of process improvements to determining ROI.
- **Improved staff/personnel productivity is ranked in the top three by roughly one third (34%) of respondents.** Labor shortages are a major concern throughout the construction industry currently, and the water sector is no exception. Given the challenges with finding skilled labor, improved staff productivity offers not just the potential for cost savings but also may help decrease risks to schedule on projects.
- **Process and productivity factors less frequently selected among the top choices include faster plan approval and permits (10%) and reduced cycle times for project activities (7%).** These may score lower because they have fewer far-reaching project impacts than the previous choices. Also, only some planning departments currently have expedited approvals for projects that submit models.

### Most Important Factors Determining ROI From BIM Use on Water Projects (According to Respondents Measuring ROI)

Dodge Data & Analytics, 2018



### Quality and Design

About one third (34%) of engineers, contractors and owners either select improved design solutions and completed project performance and quality as being among the top factors that determine BIM ROI on water projects. This corresponds with the finding that better design solutions is the top project outcome benefit experienced by respondents from BIM use (see page 20). It demonstrates that respondents recognize the wide-ranging positive impact of improved project design, quality and performance on improving ROI, even more than specific financial factors like increased profitability or cost savings.

### Improved Project Performance

Surprisingly, factors directly reflecting improved project performance are cited by a lower percentage of respondents as factors that determine the ROI on BIM than the process and design issues. This may demonstrate that respondents think more holistically about the benefits they achieve from BIM when calculating its ROI.

- **About one quarter of respondents rank improved cost control among the top three factors determining BIM ROI.** A much lower percentage (15%) believe reduced construction cost is a top factor. This demonstrates that for many respondents working in the water sector, it is the reliability offered by BIM that they will be able to make their committed project budget that is perceived to have greater value rather than actual cost reductions.
- **12% select reduced project duration (schedule) among the top three factors.** Similarly, process and productivity factors that help contractors experience more reliable schedules are more frequently selected among the top three than direct impact on shortening project schedules. A few factors probably influence this result. First, like budget concerns, reliability for schedule may be more important than reducing schedule. Also, the process and productivity factors can influence other elements beyond schedule, making them more likely to be ranked in the top three.
- **Only 2% select positive impact on sustainability as one of the top factors impacting the ROI of BIM.** Sustainability is an important consideration for many water projects, but it may not help directly with ROI to the degree that many of the other factors in the study contribute to it.

### Increased Profitability

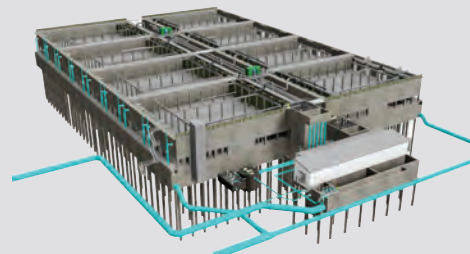
Nearly one quarter (22%) select increased profitability as one of the top three factors contributing to BIM ROI on water projects. Unlike reduced construction costs, which could ultimately benefit the owner, increased profitability is a direct business benefit for engineers and contractors. However, the fact that is not cited by more suggests that some of the BIM benefits may be helping companies to be more competitive in a relatively tight sector, rather than directly increasing their profit margin on projects.

# Demonstrating the Benefits of BIM on First Try

## Liverpool Wastewater Treatment Works

LIVERPOOL, UK

THE BUSINESS VALUE OF BIM FOR WATER PROJECTS



Aerial view and detail of the Liverpool Wastewater Treatment Works.

To execute the £150 million expansion of the Liverpool Wastewater Treatment Works in Liverpool, UK, the design and construction team faced major challenges, but also saw significant opportunities. A joint venture of Galliford Try, Costain and Atkins aimed to deliver the new facility within a constrained site, which was also protected under English Heritage preservation status. At the same time, the firms faced upcoming BIM mandates from the UK government, but they hadn't previously used BIM on water projects. "Each company wanted some BIM experience," says Paul Heath, principal technician at Atkins. "This seemed to be the perfect candidate."

The team needed to design and build a new plant next to existing facilities and within the confines of an operational dock on the River Mersey. The centerpiece of the expansion is a new 160-meter-long, 120-meter-wide and 25-meter-high

sequence batch reactor. The SBR features eight treatment cells stacked on another eight treatment cells. The structure sits on roughly 860 continuous flight auger piles. Because of its protected status, the walls of the dock could not be damaged during construction. A permanent closure was built around the site before it was dewatered and filled with sand.

### Adopting BIM

BIM was not considered during the concept and definition phases of the project by the client, United Utilities. However, Heath says the team chose to use BIM to help it head off potential issues—saving time and money in the process.

Resistance to adoption of BIM—both within its own team and among its partners—proved to be the first big challenge on the project. "When we got there, people were reluctant," he says. "They thought it would take too long and cost too much. We were told to bring in draftsmen and do it in

2D, but we decided to do it our way and prove that it could be done. We provided 2D drawings at first, but showed them that those drawings were generated from a 3D model. When they saw what we could do in 3D, we were told to carry on."

### Enhanced Communication and Visualization

Starting with the structure, Heath says the team modeled piles and wall kickers. Very early on the team began sharing models, including exchanging models with a reinforcement detailing group based in India.

The visualization benefits of BIM paid off early, too. Heath says modeling was used to help redesign portions of the basement and create new bays where operators could work entirely inside the building. "We had the 3D virtual world to show the client that this would work," he says. "That resulted in about a £250,000 value engineering opportunity. The improved



## Liverpool Wastewater Treatment Works

LIVERPOOL, UK

collaboration was very valuable.”

Working in a colocated office, the project’s engineers, contractors and client representatives could easily collaborate on models. While a modeler was creating a sump, Heath says a mechanical engineer walked by, saw the model and realized it was too small. “[The mechanical engineer] gave the modeler some dimensions,” Heath recalls. “Within seconds it was enlarged to the dimensions he had been given. The mechanical guy called over the process guy, who said it still wasn’t big enough. Next thing you know, the structural guy is coming over and then others started to come over. The modeler sat there with six guys behind him. As they were saying what their requirements were, he was filling it with equipment and stretching it. It was taking shape in front of their eyes and they couldn’t believe it. They said, to a man, that this is the way we should be doing things. We won the hearts of everyone on the team.”

### Using BIM for Construction

Heath says the reputation of the modelers “grew exponentially from that point” and the construction team asked to expand the BIM efforts. Due to inclement weather, the new reactor was roughly six weeks behind schedule. Modelers were able to add construction activities to their federated model and create a 4D timeline that helped the construction team catch up on schedule.

One way the team decided to expand BIM was to require suppliers to provide 3D models. Despite some initial resistance, suppliers agreed. “We all said, we’re on a

journey together,” Heath says. “The government wants us to work this way. We’re starting on this journey. We don’t understand everything, but come with us and learn with us.”

By then extending into construction modeling, even more value was achieved. Heath says that hundreds of clashes could be expected in the field under a more traditional approach. “There were very few clashes,” he says. “You consider that it’s easily at least £1,000 per clash with the construction downtime and alterations to the design. You can soon build up huge costs just on clashes.”

Through improved clash detection, Heath says the construction team had more certainty when fabricating steel and other building elements. The new facility also includes extensive epoxy-coated pipeworks that needed to be precisely designed and fabricated. “Once a piece of pipe has gone through that process, if you make a cut, you now have a point of corrosion,” he says. “We didn’t want any cutting onsite. No waste.”

The construction team was also able to access the model from the field with iPads to help monitor, identify and solve issues.

Although 5D (i.e., cost data integrated with BIM) was not used on the project, the team did run successful experiments to test concrete pricing. “We showed it to the quantity surveyors, and at first they weren’t interested,” Heath says. “Twelve months later, when they saw what we could do, they realized they missed an opportunity.”

When completed, the federated model included more than 450 individual models. Despite those extensive efforts, Heath estimates

that the project would have required around twice as many draftsmen to draw the project in 2D versus its team of 3D modelers.

Although a BIM deliverable was not mandated by the client, the joint venture provided United Utilities with its BIM model in addition to the required 2D as-built drawings. The team created a demonstration for the client to show how a 3D model could be used to navigate around the facility and conduct analysis and risk assessments. “They liked what they saw and they now require it [on projects],” Heath adds.

Atkins has also expanded its BIM offerings based on its experience on the Liverpool project, including expanded options for offsite fabrication and the potential of modularization. “This was a good proving ground for us,” Heath says. ■

### Project Facts and Figures

stats

#### Detail Design and Construction

GCA JV: Galliford Try, Costain and Atkins

#### Project Type

Expansion of existing facility

#### Overall Size

160m x 110m x 25m high

#### Flow Capacity

950 ml/day

#### Disciplines Modeled

Civil, structural, mechanical, electrical, process

#### Construction Started

April 2012

#### Project in Use

December 2016

# Data: BIM Investments

## BIM Investments

All respondents were asked to select the top three areas in which they plan to make the greatest investments in the next two years to support their use of BIM on water projects. The responses of engineers and contractors were very similar to one another and different from those of the owners.

### Engineers and Contractors

The top four investments for engineers and contractors all focus on capabilities rather than hardware/software.

- **BIM training is a major priority.** This finding is similar to the responses of engineers and contractors in the transportation sector reported in the *Business Value of BIM for Infrastructure SmartMarket Report*, and is also aligned with the finding that having more internal workers with BIM skills would have a positive impact on the benefits experienced from BIM (see pages 22 and 23).
- **Developing custom 3D libraries is also an area for investment for engineers and contractors in the water sector.** This is in contrast to the transportation sector, where creating custom libraries was a low priority.
- **Investments for improving internal and external collaboration are also ranked high by engineers and contractors.** Since the ability to work collaboratively is the top business benefit of BIM in the water sector (see page 18), it is not surprising that most companies are also investing in these capabilities.
- **Software customization is more of a priority than investments in standard BIM software or in hardware.** The relatively high number of years of experience of these respondents likely means that they are focused on improving what they have rather than on initial investments in software or equipment.

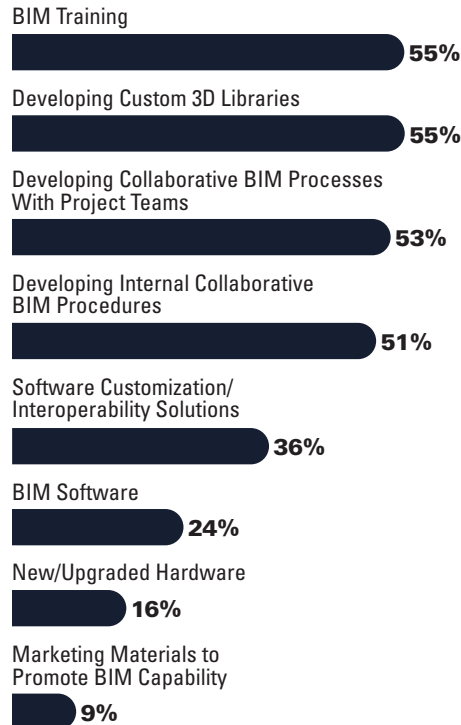
### Owners

Four areas of investment in the next two years also rise to the top for owners.

- **The highest percentage of owners (58%) expect to invest in developing BIM standards for project teams.** More widely accepted BIM standards are also perceived by many as a likely factor to improve the benefits achieved from BIM (see pages 22 and 23).
- **Similar to engineers and contractors, nearly half (47%) of owners plan to invest in supporting internal and project team collaboration around BIM.**
- **Almost half (42%) of owners also prioritize BIM training,** perhaps suggesting that they see use for BIM throughout the building lifecycle.

### Top Investments Related to BIM (According to Engineers and Contractors)

Dodge Data & Analytics, 2018



# Better Coordination Through Visualization and Data Sharing

## Tomahawk Creek Wastewater Treatment Facility

LEAWOOD, KANSAS

THE BUSINESS VALUE OF BIM FOR WATER PROJECTS



Aerial view generated in BIM of the expanded Tomahawk Creek Treatment Facility.

When Black & Veatch was selected to design an expansion of the Tomahawk Creek Wastewater Treatment Facility in 2014, the team saw an opportunity to push the limits of its BIM capabilities. The team leveraged the model for improved visualization, clash detection, quantity takeoffs, cost estimating and even the potential uses of virtual reality for water projects.

Prior to the Tomahawk Creek project, John Keller, project manager at Black & Veatch, completed two water projects using BIM technology, including one with Johnson County Wastewater, which operates the Tomahawk Creek Facility. "I knew

the tools were getting better," he says. "On this Tomahawk project, we added every piece and part [of the BIM toolbox] that we could think of into the project."

The project expands the facility's capacity from 7 million gallons per day (MGD) to 19 MGD in order to meet current and future capacity demands. The project scope includes influent junction and flow control structures; influent and peak flow pump stations; a headworks building; primary clarifiers; BNR basins; final clarifiers with associated pump stations and splitter structures; a tertiary pump station; a filtration complex; chemical disinfection; an effluent re-aeration structure; gravity thickeners; a solids process

building; solids digestion and gas storage; waste gas flares; and an administration and maintenance building.

The project, which is scheduled to start construction in 2018 and complete in late 2021, is being delivered under a construction-manager-at-risk (CMAR) method with McCarthy Building serving as the CMAR and Black & Veatch teamed with HDR on the design side. The design team began collaborating with McCarthy after completion of a 30% set of drawings.

### Beginning the Process

Early in the project, the team laser scanned existing facilities to create an accurate as-built model. "Instead of going to the old drawings from the '60s and trying to interpret from what they had done, we were able to effectively scan it in two days and created a model about a month later," Keller says. "We found the drawings from the '60s weren't as accurate as they should have been. So we got a true as-built. I don't know if it took more or less time, but the end product was better."

### Coordinating Data

Black & Veatch handled most disciplines in-house, including architectural, structural, electrical, mechanical and HVAC. Keller says that approach enabled the team to create a seamless model. "We have one model, so when the mechanical person puts in the ductwork, they will see the electrical lights and piping, too. All of the disciplines are there [in one model]."

The firm also shares a common data storage location with HDR, says Brian Melton, BIM/technology

CONTINUED

## Tomahawk Creek Wastewater Treatment Facility

LEAWOOD, KANSAS

evangelist with Black & Veatch. Melton established a project “portal,” where team members could access complex data in a more simplistic fashion. “It allowed us to federate better with our partners,” Melton says. “As [designs] continue to get more complex heading into the future, we’re looking for ways to simplify the way people interact with that technology. The portal is one way to do that. A few clicks and you get access to model data, whereas before it was trapped behind a specialist who had to know the application to get access to it.”

### Challenges

Working in a collaborative environment, the team was able to leverage the model for tasks like clash detection, quantity takeoffs and cost estimating. But those efforts weren’t without their challenges. “If you didn’t code [attributes] right—like you coded a wall as slab on grade—you’d see that [the quantities] were far off,” Keller says. “You had to be really spot on in coding things. What we ended up doing was, the BIM coordinator would pull up the quantities, he’d send them to our engineer for review and make sure they looked OK. If they did, then we’d pull the quantities and give it to our estimating group. It wasn’t as fast as I thought it would be. I thought for quantities, you would push a button and it would happen. That was not the case, and it took a while. That was a big lesson learned.”

### Improved Visualization

Keller says the portal has enabled improved communication and collaboration with the client. “I can pull the model up on my phone

to show clients the drawing set,” he says. “They can look at it and comment on it to a point that, when my design staff now pulls up the model, if they see something wrong they take a photo, they mark it up and send it to the CAD technician.”

The improved visualization helped the design team to work better with the client during its regular meetings. By walking through the model, the team could discuss potential access and clearance issues with the plant’s engineers and other staff. “We could see if a pump was too close to a column and you couldn’t get to a valve,” Keller says. “Someone saw that a valve was 20 feet off the ground. They’ll need to access that [valve], so we lowered it in the model.”

While designing tanks for the digester complex, Keller says the client could review not only the tanks themselves, but how they would be viewed from the surrounding neighborhood. “If I didn’t have that, we couldn’t provide clarification to the owner about what we were trying to achieve,” he says.

### Virtual Reality

The team also leveraged virtual reality (VR) technology to take visualization to another level. “Internally, we used the VR with our design staff to help facilitate our review of the project,” Keller says. “We also took it to the owner and said, ‘This is what it will look like. Do you have questions or concerns?’”

Keller says the VR technology was very effective at helping the team recognize conflicts and gain a better sense of scale in the design. “People understand the space they’re designing better rather than

a model on screen,” he says. “What does a 24-inch pipe look like when you’re standing next to it, rather than looking at a drawing?”

Melton says rapid improvements in VR technology have made creating VR environments on construction projects a feasible option. “Fortunately, the tools and technology have become easy enough now to where it can keep up [with ongoing changes to the model],” Melton says. “Otherwise, we would have just done it this one time, and it would have taken a long time to convert the model environment setup. Now it’s a reality where we can easily move design data back and forth with VR. That’s where we see the opportunity with design reviews. The exchange of data in setting up this VR environment can keep up with the work that’s happening.”

Black & Veatch currently has one VR setup, but Melton says he has a long-term vision of adding VR machines to other offices around the country. “The next expansion we’re trying to do is send these hardware devices to multiple regional offices and have an environment setup where multiple people can come into a single VR environment and really do design collaboration in VR,” he says. “We have projects on a global basis that have more than three or four offices involved. VR offers opportunity to change the way we collaborate.”

Keller says he sees the potential of VR extending into staff training for the client. “The operations staff at a facility are the ones who will be using it, and they will get a sense of the facility, the clearances and how to get to pieces of equipment.” ■

# Data: Team Members and BIM

THE BUSINESS VALUE OF BIM FOR WATER PROJECTS DATA

## BIM Requirements for Selecting Project Teams

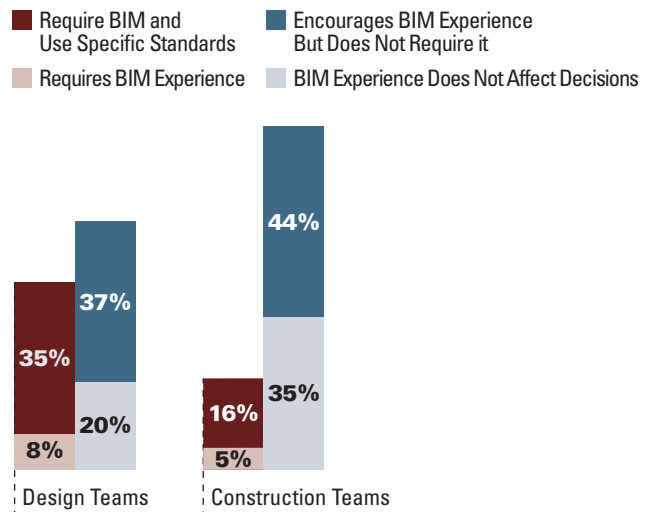
Engineers, contractors and owners were asked whether they employ BIM expertise requirements when selecting members of the design and construction team. The responses of those who are involved in selecting those teams are indicated at right.

- Nearly half (43%) report that they have BIM expertise requirements for design teams, far more than the 21% who report that they have BIM expertise requirements for their construction teams.
- Among those who have requirements for design and construction teams, it is far more common to use specific standards than to simply require BIM expertise.
- Encouraging BIM expertise is a relatively common practice among those who don't require it.

These findings reveal that, among those using BIM, looking for team members who also use BIM is a high priority, especially for the design team.

### Requirements When Selecting Design and Construction Teams (According to Respondents Who Are Involved in Selecting These Teams)

Dodge Data & Analytics, 2018



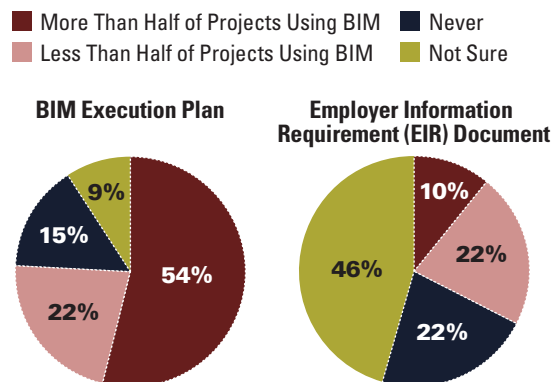
## Use of BIM Execution Plans and Employer Information Requirements (EIR)

Engineers, contractors and owners were asked how frequently BIM execution plans and Employer Information Requirement (EIR) documents were used on their water projects.

- 76% report that a BIM execution plan is used on at least some of their projects, with twice as many seeing them on more than half of their projects than those who see them on fewer projects. Using a BIM execution plan is recognized as a best practice to improve the ability of teams to maximize the benefits they achieve from BIM.
- Only 32% report that an EIR document is used on their BIM projects. More of those are also only seeing EIRs used on less than half of their BIM projects. Only one third of the respondents who report seeing an EIR on their projects are located in North America, demonstrating that use of this documentation is not widespread in the US or Canada.

### Requirements When Selecting Design and Construction Teams (According to Respondents Who Are Involved in Selecting These Teams)

Dodge Data & Analytics, 2018



Engineers, contractors and owners with experience working with different types of companies on the project team were asked to rate the general level of BIM maturity of those types of companies.

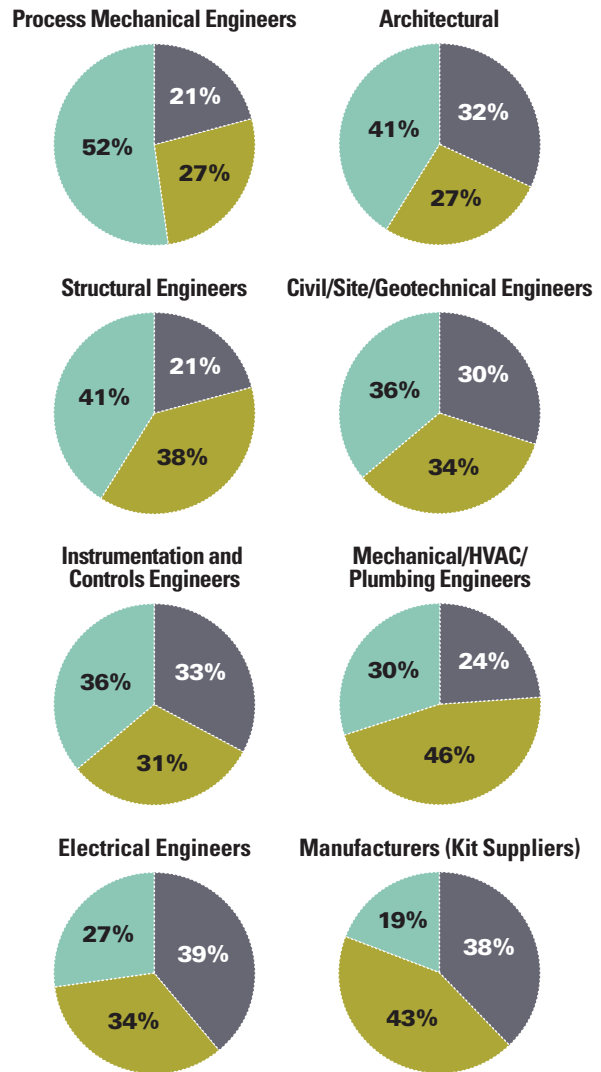
- **Process mechanical engineers are seen by the highest percentage (52%) to have an advanced/expert level of BIM maturity.** The processes for water/wastewater treatment are at the heart of any successful plant project, so it is important for overall BIM adoption in this sector that process mechanical engineers are adept at using BIM.
- **The same percentage (41%) rate architectural firms and structural engineers as having an advanced/expert level of BIM maturity.** However, more firms rate structural engineers with a moderate level of maturity than architectural firms, and conversely, more consider architectural firms to have basic BIM maturity than structural engineers.
- **Respondents are nearly evenly split between basic, moderate and advanced/expert BIM maturity for both civil/site/geotechnical engineers and instrumentation and control engineers.** This suggests a wide range of BIM sophistication across both of these professions. However, it is notable that civil/site/geotechnical engineers are considered to have a reasonably advanced level of BIM maturity in the water sector, since studies looking at their BIM sophistication in general building projects have typically rated them much lower than many other project team members.
- **While only 30% rate the BIM maturity of (non-process) mechanical engineers in the water sector as advanced/expert, a relatively high percentage (46%) find them to be a moderate level.** Mechanical engineers have tended to rank much higher among project team members on studies in general building, suggesting the very different use of BIM in the water sector.
- **Electrical engineers and manufacturer kit suppliers rank lowest in terms of BIM maturity among the team members included in the study.** Electrical engineers are also typically low-ranked in general building studies. This is the first measure of manufacturers, and few see kit suppliers for water as possessing high BIM maturity.

## BIM Maturity of Project Team Members

### Level of BIM Maturity for Types of Companies on Project Teams (According to Respondents Who Are Involved in Selecting These Teams)

Dodge Data & Analytics, 2018

- Basic (3D Used to Create 2D Drawings)
- Moderate (Exploring Use of BIM Data)
- Advanced/Expert (Use of BIM Data Throughout Some Phases or All of the Project Lifecycle)



## Project Outcome Benefits Derived From BIM Use by Experienced Project Team Members

Consistently, studies of BIM use by Dodge Data & Analytics, both in other sectors in the US and globally, have demonstrated that having other project team members experienced with and using BIM amplifies its benefits, and these findings demonstrate that the water sector is no exception.

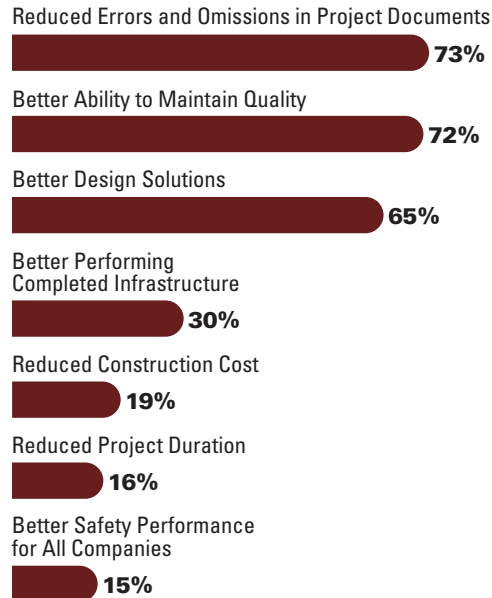
All respondents were asked to select the top project outcome benefits they are able to achieve when they work with project teams experienced in BIM. The top three benefits of BIM experienced teams are the same as the top three experienced from their own use of BIM. (See page 20 for the top project outcome benefits of BIM use reported.)

- **Reduced errors and omissions in project documents is selected among the top three by 73%.** This is noticeably more than the 57% who select it as a top project outcome benefit of BIM use in general, demonstrating the importance of team use of BIM, rather than use of BIM in isolation, to achieve this benefit.
- **Nearly as many (72%) report that BIM-experienced project team members gives them a better ability to maintain project quality.** Again, this is a big leap over the percentage who report this as a top benefit just from their own use of BIM (42%).
- **Nearly two thirds (63%) also find the BIM-experienced project teams create better design solutions.** Unlike the previous two benefits, this number is comparable to those (68%) who report that this is a top benefit from their own use of BIM.

Far fewer select the other possible project outcome benefits, like better safety performance, reduced project duration and reduced cost. However, as noted previously, respondents were asked to identify the top three benefits, not all the benefits they achieve from a team experienced in BIM. Certainly a project with reduced errors and omissions is better able to achieve the planned cost and schedule, and everyone benefits from the ability to produce a better project, especially clients, that an experienced BIM team clearly makes possible.

### Top Project Outcome Benefits Derived From BIM Use by Experienced Project Team Members

Dodge Data & Analytics, 2018



## Project Process Benefits Derived From BIM Use by Experienced Project Team Members

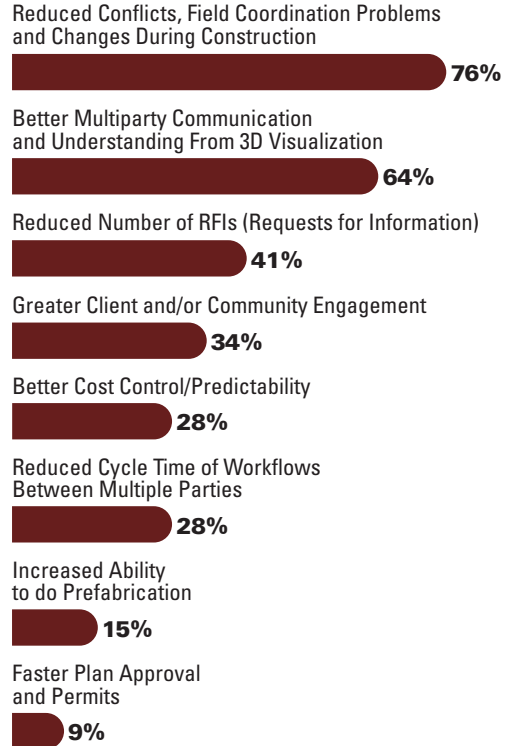
In addition to the top outcome benefits, respondents were asked about the top three ways in which their project process was improved by working a project team that is experienced in BIM. The findings demonstrate how BIM improves communication across teams and reduces conflicts.

- **Over three quarters (76%) find great value in how a BIM-experienced project team reduces conflicts, field coordination problems and changes during construction.** Ideally, the shared model can reduce or even help eliminate communication problems that have often plagued construction projects.
- **Nearly two thirds (64%) also consider better multiparty communication and understanding from 3D visualization to be one of the top three process improvements achieved by a BIM-experienced project team.** This is the only other process benefit selected by over half, and it demonstrates the ability of BIM to allow complex aspects of design and construction to be more easily conveyed through 3D visualization, allowing better coordination between designers and the field, as well as between the design and construction team and the client.

As with the project outcome benefits, the top choices also have the potential to help teams achieve some of the more specific benefits selected by fewer respondents. In this case, fewer conflicts, enhanced communication and understanding can contribute to fewer RFIs, greater client/community engagement, better cost control/predictability and reduced cycle time of workflows. Since respondents were asked to only select their top three process improvements, it is not surprising that they favored those that help yield the other benefits.

### Top Project Process Benefits Derived From BIM Use by Experienced Project Team Members

Dodge Data & Analytics, 2018





## In the Pipeline: Design-to-Fabrication

**One firm's experience demonstrates the potential and challenges inherent in design-to-fabrication.**

**S**acramento Regional County Sanitation District's \$1.75 billion upgrade to its wastewater treatment plant, known as EchoWater, is using BIM from predesign through asset management to envision, construct and operate the facility more effectively. One of the ways in which the project is innovating with BIM is design-to-fabrication. (For more information on the EchoWater project, see the case study on pages 16–17.)

When Livermore, California-based pipe fabricator Jifco won the \$20 million contract to supply EchoWater, the company was already in the process of transitioning to 3D. Having tracked its internal errors and costs over a five-year period, Jifco knew that it was spending \$250,000 to \$300,000 per year on drafting errors alone, a cost that the coordination advantages of working in 3D would just about eliminate.

"In a 2D world, nothing's interconnected," says Larry Vieira, engineering manager at Jifco, and that's how errors creep in: something gets moved on a profile but not on a plan view; markups come back from the engineer, and the same thing happens again. "If we have to spend \$100,000 per year on training BIM, but we're going to save a quarter of a million dollars in errors, shop time and customer confidence, it's a clear and easy path to take," he says.

### **The Boulder in the Road**

Or so he thought. The reality has proven much more challenging, in large part because they need to make the BIM software used on the project as a whole adapt to the particular needs of piping—especially at the scale of pipe Jifco works with. "Oversize pipe with unique linings, coatings, joints and welds gets complicated real fast," says Charlie Forni, project manager at Jifco. With 95 percent of Jifco's work consisting of custom pipe at diameters up to 167 inches—which is well above the 12-inches-and-smaller diameters popular BIM software does well—generating 3D drawings that can be dropped directly into the EchoWater project model has taken time and ingenuity.

In terms of EchoWater's overall cost, Jifco's contract may be small, but it is crucial. "We have to be spot on," says Forni, "That to us is the advantage of 3D." To reap the benefits of coordination and clash detection in 3D, Jifco is using families and working with the software's API to program around the stumbling blocks, and has retained a third-party consultant to support its in-house team with research and consultation. "I think we're doing pretty well," says Vieira of their design-to-fabrication efforts in software that's not set up for what they do. "If you take [BIM] out of the box and try to draw some of the stuff we're drawing with it, you'll never do it."

### **Beyond Modeling**

What Vieira and Forni are really looking forward to are the advantages of applying BIM to the entire fabrication process, from estimating to delivery. That includes ordering and receiving material, and tracking a job's progress through fabrication, including who builds it, when and how, with similar tracking for welding, linings and coatings, inspections and testing, and any loose parts as it ships out the door. BIM will capture all these aspects of the business model, which Jifco currently tracks manually, and provide information in real time. "There'll be no more hand counting errors or typos," says Forni. "You're ordering the right part as you drew it in the model—and that will be a huge speed-up for our shop."

In a first for the industry, as far as Vieira and Forni know, Jifco is even using BIM as an estimating tool, before converting to a project management tool as an order progresses. To date, the company has successfully piloted a job from estimating through drawing and submittal in BIM, and now has a second pilot under way. Vieira expects it will take about two years to achieve the company's full vision. Despite the challenges of the transition, he says, "we've found the benefits of 3D outweigh the costs dramatically." ■

# Expanding BIM Use Through Design and Operations

## Plant D Expansion at Bonnybrook Wastewater Treatment Plant CALGARY, CANADA

THE BUSINESS VALUE OF BIM FOR WATER PROJECTS

**A**s the largest cold-weather biological nutrient removal (BNR) plant in the world and one of the largest BNR plants in Canada, the Bonnybrook Wastewater Treatment Plant has long served as an advanced treatment facility for the City of Calgary. For design firm Stantec, Bonnybrook has also offered a way for the company to advance its use of BIM in the water sector. With its latest project, Plant Expansion D, the firm leveraged ways to save time and money, while creating a rich database of facility information that the city could use for future operations.

### Early BIM Use at Bonnybrook

Starting in 2010, Stantec began testing BIM at the facility on expansion and upgrade projects—some of the water group’s first projects to use BIM. On a headworks project, the team used BIM internally for modeling its architectural, structural and mechanical design, but ultimately provided 2D deliverables. “It wasn’t really a BIM workflow,” says Chris Redel, associate at Stantec.

With each subsequent project, Redel says the firm deepened its use of BIM. “It became ‘de rigueur’ to model every element,” he recalls. “It became easier for us to get decisions made, and city engineers liked being able to visualize in 3D.”

### Planning in BIM

Following several successful BIM efforts, Redel says the city began to recognize BIM’s potential to provide multiple benefits for its design and construction team, as well as its own planning, operations and

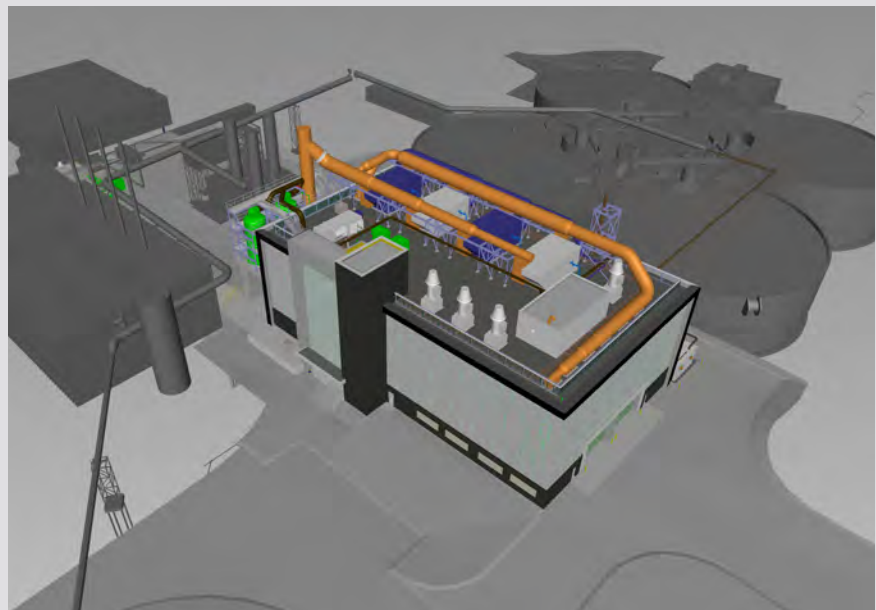
maintenance purposes. “Things started to change with Plant D,” he says. “There was more talk [with the client] about ‘what can BIM do for us?’”

The massive \$500 million Plant D expansion aims to deliver a complex collection of components to the existing facility, including:

- Primary influent conveyance, primary treatment and primary effluent conveyance
- Biological nutrient removal
- Secondary clarification
- Effluent filtration
- Ultraviolet disinfection
- Flood protection
- Plant outfall
- Chemical and process utility systems
- Secondary sludge thickening, secondary sludge dewatering, thermal hydrolysis of dewatered waste activated sludge, sludge blending and sludge digestion
- Biogas management

- Associated electrical, instrumentation and control, civil, architectural and mechanical requirements

Although the firm had previously used a combination of 2D and 3D tools, Plant D was its first use of parametric and intelligent components in its design work at Bonnybrook. Multiple engineering firms also needed to collaborate on the design. Stantec Consulting is the prime consultant with CH2M Hill, AECOM and WPC Solutions serving as key sub-consultants. Stantec was involved in modeling all major disciplines, including architectural, structural, mechanical, process, electrical and civil. AECOM and CH2M Hill also consulted on several of those disciplines. The firms colocated key players and most of the production staff in a shared project office, including the construction manager, preconstruction team and



Plant D Expansion at Bonnybrook Wastewater Treatment Plant.

## Plant D Expansion at Bonnybrook Wastewater Treatment Plant

CALGARY, CANADA

the city's project management team. The firms shared models on one common server located at the project office, which also offered remote access to users.

Having a colocated team using BIM on a shared server enabled the team to quickly make design changes in the model and update designs automatically. "We maximized collaborative efforts," Redel says. "It's nice to be able to sit next to the engineers and project managers and be able to make decisions quicker."

### Benefits of BIM Use

Redel says the entire process resulted in significant time savings. The team realized faster turnaround on visualizations from models. Improved coordination also saved time on technical reviews and provided faster production of deliverables.

The design team used BIM to do early clash detection and quality assurance. It also leveraged the model for quantity takeoffs to develop probable costs at various phases of the project.

Redel estimates that the reduced effort in drawing coordination due to model reviews and clash detection saved the team about 138 hours. The design team saved a total of approximately \$100,000 in reduced labor costs and \$17,000 in productivity improvements through automated report creation.

### Project Owner and BIM

Although BIM use was extensive within the design team, it was not required for contractors on the project. However, the design model was provided to contractors for reference and use, Redel says.

Ultimately, Stantec will provide the design model to the owner, but "not with the level of detail of a construction model," he adds.

Still, Redel says one of the most notable developments during the project was the engagement of the client in the process and their interest in pursuing additional uses of BIM in the future. "There was always some engagement with them in the past, but much more on this project," Redel says. "Part of it was the ease of visualization we could provide. Because of that, we got more people in the room. They didn't need to send someone who was savvy with the drawings. They could send their best-thinking maintenance people to the meetings and have them walk through the model and get them to understand better."

Although the client will not receive a detailed "construction-level" model of the Plant D project, early in its preliminary design, Redel says the client began exploring the capabilities that a detailed model could provide on future projects. Stantec held workshops with the city and its maintenance group to familiarize them with BIM capabilities for operations and maintenance. Subsequently, the city developed a committee to explore how BIM could be implemented into its facilities management system.

"As a large system, they couldn't make significant changes, so we did a modified COBie [Construction Operations Building information exchange] export of information," Redel says. "Most of the changes involved what we asked the contractors to provide. That's where the modified COBie database came in with the goal of providing timely

information, not just for longer-term facility maintenance, but also for commissioning."

To reduce paper submittals, the team required contractors to provide project data in digital formats that could be used by its facilities management system. "They didn't want to abandon their existing system," he says. "But they did want to improve the transfer of data and more efficiently capture that data. The city has a long-term goal to improve operations and maintenance using BIM."

While in the past, Stantec was driving BIM use at Bonnybrook, Redel sees the city taking an active role in how BIM will be used going forward. "It takes time to adopt these processes, but it's growing," he adds. "More and more projects are going this direction." ■

### Project Facts and Figures

#### Design Team

Stantec (Prime), CH2M (now Jacobs) and AECOM

#### Treatment Capacity Upgrade

30% increase or 135 MLD average/325 MLD peak flow

#### Construction Completion

Projected 2022

stats

# Interview: Thought Leader



Guy Voss

Director, Business Development,  
McCarthy Building Companies Inc.

**With nearly two decades of experience in the engineering and construction industry, Guy Voss directs strategic planning and new market growth for McCarthy's water group.**

## How would you describe the level of BIM maturity in the water sector?

**VOSS:** I've had about 17 years in the water industry, and in that time period, I would say that the water industry overall has exponentially matured to embrace and utilize BIM more fully than I've seen ever before.

Breaking the water industry into design versus construction, I've seen the design side steadily increase, [but] I've seen the construction side exponentially increase in the implementation of BIM technology over the past four to five years.

## What has been responsible for "the exponential growth of BIM sophistication" in the construction side of the water sector?

**VOSS:** Dollars and risk. By digitally building things in a BIM environment before mobilizing the workforce, you're reducing risks, finding challenges earlier and reducing costs. You're able to build it and rectify things digitally before you have the guys in the field doing it, and before you've ordered materials.

## What are the most compelling benefits that BIM currently offers to the water sector?

**VOSS:** The top [benefits] are overall better communication and coordination across the teams of owners, partners... Now that I'm in the construction side, I would also translate this to more effective

design and construction execution earlier. Finding and solving problems earlier leads to more efficient and effective execution, [and], I would say, ultimately a higher quality end product.... And one thing I'm seeing more and more is longer-term knowledge sharing in the form of better implementation and use of digital as-builts. Using BIM, not just for design and construction, but handing [the model] to the owner in the digital form as an as-built.

## What are the biggest potential benefits for BIM in this sector in the future?

**VOSS:** BIM may allow owners to more readily embrace collaborative delivery, which then may have owners ultimately choose a more collaborative delivery procurement, such as progressive design-build or CMAR versus a traditional design-bid-build procurement. I could see how BIM will allow people to collaborate better and more openly. That [improved collaboration] helps owners choose to have an overall more collaborative delivery approach.

## Do you see owners in the water sector now having BIM requirements?

**VOSS:** For the first time, and minimally, I've seen owners having BIM requirements in their own standards. Unfortunately, those standards are, at times, less than vetted and cause some challenges,

but at least it's a good first step for an owner to say, "Thou shalt use BIM tools on my project and here's a little bit of guidance on how you will use BIM." I was recently at the DBIA [Design Build Institute of America] convention in Philadelphia this year, and I heard for the first time owners openly talking about version two of their standards, and how they modified them over time.

## What is the most important next step to drive wider BIM utilization in the water sector?

**VOSS:** Again, [owner use of] progressive design-build or CMAR would be the best way to increase the use of BIM and increase how BIM is used. When the team is structured for collaboration, that allows teams to integrate design, construction, fabrication, [and] supply. Ultimately the model that you hand the owner at the end is exactly what you thought and built. I really believe that owners choos[ing] to procure projects in a more collaborative way will be the best way to increase the use—and better the use—of BIM. ■

# Interview: Thought Leader



Michael Etheridge

Global Chief Engineer, Water, Black & Veatch

**Mike Etheridge is responsible for developing and maintaining standards and tools to support design efficiency and quality for Black & Veatch's Water business line.**

## How would you describe the level of BIM maturity in the water sector?

**ETHERIDGE:** Water is lagging a bit behind building-related industries. There certainly is interest in BIM, but how it's deployed or the best way to leverage it in the water industry still is being hashed out.

## What types of companies are leading the way in the use of BIM for the water sector?

**ETHERIDGE:** No one [type] necessarily stands out. The client base of the water industry is pretty local and fragmented. The supply chain is also fragmented and regional. Each individual AEC firm tends to optimize how they use BIM for their own purposes, and maybe for specific clients. [Even engineers and owners who lead in using BIM are] focused on how can they configure BIM to suit their purposes best, as opposed to a broader utilization of BIM.

## What are the other main obstacles to increasing BIM use in the water sector?

**ETHERIDGE:** A lot of water clients are municipalities that still adhere to the traditional procurement approach of design-bid-build .... That design-bid-build delivery mechanism makes it difficult [for engineers] to integrate well with the supply chain and to give them information in a manner that's easy for them to use it as part of their bidding or construction purposes

because the bid documents have to be fairly general and open for almost anyone to bid.

When you look at other delivery methods like design-build where the engineer has an opportunity to directly interface with the contractor, [you] see more opportunities there for BIM to be more useful for the project, and for BIM to grow in terms of its capabilities within the water industry.

## What specific benefits does BIM offer for the water sector?

**ETHERIDGE:** Increased accuracy in bidding, if you can get to the point where the BIM model can be used directly by the contractors for quantity development, for work sequencing, to help put their bids together. During construction, [BIM can] help improve quality, reduce change orders and provide better visibility from the contractor's use of the model for actual construction as opposed to just being used to produce 2D deliverables that they use to build from. [To achieve] increased efficiency, better transfer of information during the bidding and construction phases, [the water sector] probably needs a bit more procedural definition to make it more consistent from project to project.

## What is the most important next step to drive wider BIM utilization in the water sector?

**ETHERIDGE:** You need to find a way, whether that's through making sure

that water is a bigger part of the [UK] national BIM standards. Or maybe [we need] a technical committee as part of that national BIM standard that's focused on water, with key people [participating] from the design, construction and owner [organizations] who agree what the standards will be, whether that's sticking directly to the national BIM standard or modifying those slightly for the water industry. But it has to be coordinated at a national level as opposed to each owner, each AEC firm, each contractor deciding how best to leverage BIM just for their own internal usage.

## What do you think will ultimately drive wider use of BIM for water projects?

**ETHERIDGE:** Owner requirements will ultimately drive it. Water's a pretty conservative industry ... Owners [need] to realize that there are potential benefits in better ... and broader adoption of BIM. Owners must be convinced that they [need to] require the use of BIM in a more structured way on their projects, and that'll drive the use of it through the industry. From a construction perspective, and from an O&M perspective, if this is done correctly, not only does [BIM] help us build your facility, but a lot of that information in the model can then be used as part of your asset management, your maintenance management, your long-term operation of your facility. ■

# Methodology:

## Business Value of BIM for Water Research

The purpose of this study was to examine BIM use, implementation, benefits, investments and ROI for firms using BIM on water projects. Topics on the survey included history and experience with BIM, types of water projects using BIM, current and future use, project and process benefits derived from BIM, ROI from BIM, anticipated investments in BIM and the role of BIM in choosing construction partners.

### Survey Distribution

An online survey was conducted from August 29, 2017 to January 23, 2018. It was sent to companies working in the water sector from the Dodge Data & Analytics Players database, and it was also distributed by Autodesk, Black & Veatch, eBuilder, the American Water Works Association (AWWA), buildingSMART Singapore, the BIM4Water Group, the National Association of Clean Water Agencies (NACWA), the National Association of Water Companies (NAWC) and the Water Environment Federation (WEF). Firms of all sizes that did work on water projects in the past three years were included in this sample.

### Respondent Profile

A total of 74 responses are included in the final analysis. The majority of respondents (81%) were located in North America, with the rest from Asia and Europe.

Respondents were classified into one of the three groups based on reporting of their primary function in 2017.

- 19 owner firms
- 30 design firms (referred to as engineers in the analysis in the report)
- 25 contractor firms

The total sample size used in this survey benchmarks at a 95% confidence interval, with a maximum margin of error of 11.4% for dichotomous items.

### Requirements to Participate in the Study

Respondents had to work on at least one of the following types of water projects: water/wastewater treatment, tunneling, linear infrastructure/utilities/collection/distribution, hydroelectric, or mining/industrial. Many firms worked on multiple project types.

Respondents were also required to use BIM on their water projects. For the purposes of this study, BIM use is defined as authoring models and/or working with models authored by others.

The nature of the requirements for participating in the survey led to primarily large firms being qualified respondents, with 81% of respondents working for companies with 500 employees or more.

### Analytical Variables

Two analytical variables are used throughout the report for analysis. The first is the primary function of the respondents of engineer, contractor or owner, described in the respondent profile.

The second analytical variable is the number of years using BIM, which generally correlates with the level of BIM expertise.

- 5 years or less: 55%
- More than 5 years: 45%

### Comparisons to Transportation Infrastructure Study

Where appropriate, this study also contains comparisons to findings from the Business Value of BIM study conducted among respondents working in transportation infrastructure in North America and Europe. Those findings are published in the *Business Value of BIM for Infrastructure 2017 SmartMarket Report*. ■

## Resources

**Organizations and websites that can help you get smarter about using BIM for water projects and the value to be gained from its use.**



### **Dodge Data & Analytics**

Main Website: [www.construction.com](http://www.construction.com)

Dodge Global Network:

[www.construction.com/products/dodge-global-network](http://www.construction.com/products/dodge-global-network)

Research & Analytics:

[www.construction.com/products/dodge-research-analytics](http://www.construction.com/products/dodge-research-analytics)

Sweets: [www.construction.com/products/sweets](http://www.construction.com/products/sweets)

SmartMarket Reports:

[www.construction.com/toolkit/reports](http://www.construction.com/toolkit/reports)

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We also thank all the individuals and organizations who contributed their experiences, data and images for publication in the case studies, along with those who agreed to provide their insights in our feature articles and thought leader interviews.



Autodesk  
[www.autodesk.com/bim](http://www.autodesk.com/bim)



Black & Veatch  
[www.bv.com](http://www.bv.com)

### **Supporting Partner**

eBuilder: [www.e-builder.net](http://www.e-builder.net)

Pinnacle Infotech: [www.pinnaclecad.com](http://www.pinnaclecad.com)

### **Research Partners**

American Water Works Association (AWWA): [www.awwa.org](http://www.awwa.org)

British Water BIM4Water Group: [www.britishwater.co.uk/bim.aspx](http://www.britishwater.co.uk/bim.aspx)

buildingSMART Singapore: [www.buildingsmartsingapore.org](http://www.buildingsmartsingapore.org)

National Association of Clean Water Agencies (NACWA): [www.nacwa.org](http://www.nacwa.org)

National Association of Water Companies (NAWC): [www.nawc.org](http://www.nawc.org)

Water Environment Federation (WEF): [www.wef.org](http://www.wef.org)

### **Information about BIM Execution Plans**

Penn State BIM Execution Planning: [bim.psu.edu/Project/Procedure/default.aspx](http://bim.psu.edu/Project/Procedure/default.aspx)

### **Information about Employers Information Requirements (EIR)**

Scottish Futures Trust Create the Employers Information Requirements: [bimportal.scottishfuturestrust.org.uk/level2/stage/2/task/8/create-the-employers-information-requirements](http://bimportal.scottishfuturestrust.org.uk/level2/stage/2/task/8/create-the-employers-information-requirements)

NBS BIM Toolkit Employers Information Requirements: [toolkit.thenbs.com/articles/employers-information-requirements](http://toolkit.thenbs.com/articles/employers-information-requirements)

### **Other Resources**

BIMForum: [bimforum.org](http://bimforum.org)

BIM Level 2: [www.bim-level2.org](http://www.bim-level2.org)

bimSCORE: [www.bimscore.com](http://www.bimscore.com)

buildingSMART International: [www.buildingsmart.org](http://www.buildingsmart.org)

National Institute of Building Sciences: [www.nibs.org](http://www.nibs.org)

■ Design and Construction Intelligence

# SmartMarket Report

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